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TWENTY-THIRD
ANNUAL REPORT

OF THE

FISHERY BOARD FOR SCOTLAND,

Being for the Year 1904.

IN THREE PARTS.

PART I.—GENERAL REPORT.

PART II.—REPORT ON SALMON FISHERIES.

PART III.—SCIENTIFIC INVESTIGATIONS.

PART III.—SCIENTIFIC INVESTIGATIONS.

Presented to both Houses of Parliament by Command of His Majesty.



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WENTY-THIRD

THE REPORT

SHEET BOARD FOR SCOTLAND

Being for the Year 1904

IN TWO VOLUMES

PART I—GENERAL INVESTIGATION
PART II—LOCAL INVESTIGATION

ARTS—SCIENTIFIC INVESTIGATIONS

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1905

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TWENTY-THIRD ANNUAL REPORT.

TO THE MOST HONOURABLE
THE MARQUESS OF LINLITHGOW, K.T., G.C.M.G.,
His Majesty's Secretary for Scotland.

OFFICE OF THE FISHERY BOARD
FOR SCOTLAND,
EDINBURGH, 30th June 1905.

MY LORD MARQUESS,

In continuation of our Twenty-third Annual Report,
we have the honour to submit—

PART III.—SCIENTIFIC INVESTIGATIONS.

GENERAL STATEMENT.

This part of the Twenty-third Annual Report deals with the scientific investigations conducted by the Board in 1904 in connection with the sea fisheries of Scotland, so far as these have been completed, by means of the Parliamentary Vote granted for the purpose.

The scientific work has been carried out and the scientific report prepared under the supervision of Dr. T. Wemyss Fulton, the Scientific Superintendent.

The researches have been made for the most part at the Board's Marine Laboratory at the Bay of Nigg, Aberdeen, which was erected and equipped some years ago. The sea-fish hatchery is also situated at the same place, and a statement as to its operations during the year will be found below. The provision of a suitable boat in connection with the Laboratory would be of much advantage in carrying on the investigations.

The investigations into the condition of the fishing grounds, more particularly in the Moray Firth and Aberdeen Bay, which were begun five years ago by means of steam-trawlers, were continued last year as frequently as circumstances allowed. One of the chief objects of these trawling investigations is to ascertain as far as possible the changes which may occur in the abundance of the

food and other fishes on the grounds visited in different years and at different seasons, but observations are also made on the reproduction of the fishes, their spawning, food, and on various other questions connected with their life-history and habits, and at the same time collections of the plankton, or floating organisms, are obtained, and experiments made with large-meshed and small-meshed nets.

Although the employment of commercial vessels in these investigations is associated with certain inseparable disadvantages, it is possible with the large ship, the efficient trawl, and the experienced trawlers on board, to make a much more thorough examination of the bays than was formerly the case. From the fact, moreover, that the trawling operations are carried on under the same conditions as in commercial fishing, opportunities are afforded for certain observations of importance, as the proportion of the marketable and unmarketable fishes which are caught, the relation between the sizes of the fishes captured and the dimensions of the meshes of the net, and the amount of destruction of immature fish that occurs on different grounds and at different seasons.

For some years past, as mentioned in previous reports, by an arrangement with the Technical Education Committee of the County Council of Aberdeenshire, representative fishermen from various parts of the coast of that county have visited the Laboratory and Hatchery in spring to receive demonstrations on various aspects of the life-history and habits of fishes, such as may be of interest and use to them in the course of their calling. The fishermen have been much interested in the instruction they received, and as it appeared to the Board advantageous to encourage the desire for such knowledge on their part they issued a circular to the other sea-board County Councils inviting them also to send fishermen if they thought proper so to do, to attend a similar series of demonstrations. This invitation was accepted by the County Council of Argyleshire, a number of fishermen from that shire subsequently visiting the Laboratory and Hatchery, and it is under consideration by some of the others.

TRAWLING INVESTIGATIONS.

In the course of the year the results of 91 hauls of the large otter-trawl in the closed waters were recorded, of which 75 were taken in the Moray Firth, 14 in Aberdeen Bay, and two in Sand-side Bay, on the north coast. The examination of the grounds was made in January, March, April, September, October, November, and December, the localities in the Moray Firth which were most thoroughly investigated being Burghead Bay and adjacent parts of the south coast, the Dornoch Firth, and the grounds off the coast of Caithness. Some hauls were also taken at Smith Bank and in the deeper portions of the Firth at the so-called "witch-grounds."

The aggregate number of fishes of all kinds caught in the recorded hauls was 63,525, and of these 44,538, or 70 per cent., were marketable, the other 18,987, or 30 per cent., being thrown

overboard as unmarketable, either because they belonged to species that are unsaleable, or, more commonly, because though edible they were too small to be taken to market.

The number of fishes captured in the various hauls and the proportion of the marketable and unmarketable are given in the tables appended to Dr. Fulton's report on the subject. The greater number of the marketable fishes consisted of plaice and haddocks, the former constituting 58 per cent. and the latter 25 per cent. of the total in this class; the proportion of none of the others reached three per cent. Among the unmarketable fishes, common dabs formed 32 per cent. and haddocks 30 per cent. The total number of turbot obtained was 54, and there were 394 brill, nine halibut, and five soles, and all these were marketable. 40 catfish and 22 hake were caught, all of which were marketable.

The investigations in the Dornoch Firth at the end of March were of interest from the discovery of a shoal of spawning cod on the edge of the rough and rocky ground. Several scores of cod were taken in each haul of the net, the largest number in a four hours' drag being 282. They were all spawning, eggs and milt flowing freely from them, and they were all of large size, the smallest females measuring from 33 to 35 inches and the smallest males from 29 to 30 inches. It was judged that the vessel was operating only on the fringe of the spawning shoal and that the greater bulk of the cod were on the rocky ground. Besides the cod, large numbers of spawning flounders were caught on this ground, where few of this species are obtained except in spring, and also spawning coalfish and plaice, in smaller numbers, and common dabs; very few haddocks were obtained and none of them were spawning.

It is probable that this area, lying about three miles from the shore in from 13 to 16 fathoms, is one of the important breeding-grounds for the food fishes in the Moray Firth.

The experiments made with a small-meshed net fastened around and outside the cod-end of the trawl confirmed the conclusions come to previously, that, contrary to the general opinion of fishermen, a very large proportion of the small fish, especially round fish, which enter the trawl as it is dragged along the bottom escape alive through the meshes, which appear to be distended by the resistance of the water.

THE HATCHING AND REARING OF FOOD-FISHES.

During last year the hatching of plaice was continued at the Marine Hatchery, Aberdeen, the number of eggs of that species collected from the spawning pond amounting in the season to an aggregate of about 39,600,000. The number of plaice-fry that hatched out and were retained in the hatching apparatus until approaching the post-larval stage was approximately 34,780,000, or 88 per cent., and they were liberated off Aberdeen Bay at various times in March, April, and May. The number was considerably below the total in 1903, when it was estimated that 65,940,000 eggs were collected, the fry obtained numbering 53,600,000. The

principal reason of the decrease was the difficulty in obtaining large adult plaice in the preceding autumn and winter to replenish the breeding stock in the pond, plaice of the class required being then exceedingly and unusually scarce on the grounds from which they are obtained.

The floating eggs were observed in the water of the spawning-pond about the middle of January, but they were then present in very small numbers, and the first collection was made on the 26th of that month, or three days later than in 1903. The last collection was on the 29th April, or more than a fortnight earlier than in the previous year. This is, no doubt, partly to be attributed to the smaller number of the spawners in the pond, as above mentioned, but it appears to have been also owing to the relatively greater intensity of spawning in the earlier part of the season in 1904, nearly 28 per cent. of the eggs being collected before the end of February, as compared with 18 per cent. in the same period in 1903. As usual, the greater number of the eggs were obtained in March, viz., 55·7 per cent., the percentage in that month in the preceding year being 56·2.

The duration of the period of development until hatching takes place varies with the temperature of the water at the time. At the beginning of the season, in January, when the temperature is low, the average time of incubation is about three weeks, while at the end of the season, when the temperature is several degrees higher, they hatch in about a fortnight. The larval fishes, after issuing from the eggs, are retained in the apparatus for several days until the yolk-sac is partly absorbed, and it is calculated that, taking the two periods together—the time of incubation and the period referred to subsequent to hatching—the eggs and larvæ are protected in the apparatus for about half of the time from the spawning of the egg until the young plaice is transformed and assumes the form and habit of the adult.

Since the establishment of the hatchery, the total number of plaice eggs dealt with amounts to 443,092,000, the fry liberated numbering 363,250,000. The number of fry of other fishes produced is as follows:—lemon soles, 5,727,000; turbot, 5,160,000; cod, 4,010,000; and other kinds, 2,000,000.

Owing to the circumstance that the hatchery is worked in conjunction with the Marine Laboratory, the expense of the hatching operations at the Bay of Nigg is not large compared with the number of fry produced, the annual expenditure in connection with it being estimated at about £100. As previously stated, the establishment was visited during the hatching season by representative fishermen from the shires of Aberdeen and Argyre, to whom the various processes adopted, as well as the fertilisation of the eggs and the development of the fish, were explained.

THE GROWTH AND AGE OF FISHES.

During the last few years a considerable amount of attention has been given to the study of the age of fishes and the rate at which they grow, and a number of papers dealing with the growth and age of the plaice, cod, haddock, whiting, and other forms have appeared in the recent reports of the Board. It is a subject that

has an important bearing on several problems connected with sea fisheries.

One method by which the growth and age of fishes is determined is by the tabulation of the measurements of large numbers taken at the same time and place. From the fact that the spawning season of a species, and, therefore, the rate at which a new generation makes its appearance, is usually limited to a few months of the year, the range of the sizes and the average size of the different generations or annual series differ from one another. By the tabulation of large numbers of measurements it is thus possible to distinguish different generations and to assign the range of size and the age of the fishes belonging to them. With the earlier generations this method is in most cases quite satisfactory, but owing to the very different rate at which members of the same generation grow, the larger of an earlier generation overtaking and exceeding in size the smaller members of the next older generation—a process which increases with age—it becomes difficult or impossible to separate the older generations from one another by this method.

Another method that has of late been largely adopted consists in determining the number of the zones or lines of growth in certain of the hard parts of the body. Fishes do not grow continuously throughout the year, their growth exhibiting a usually well-marked periodicity in relation to the changes of the temperature of the water, being as a rule, and in most places, rapid in summer and slow in winter. This periodicity is indicated by lines or zones on some of the skeletal structures, notably on the ear-bones, or otoliths, the scales, and certain bones of the skeleton, the structure which shows them best varying somewhat in different species. By counting the lines or zones it is thus possible to tell the age of a fish, just as by a similar method, and for a like reason, the age of a tree may be discovered by the number of rings present in a section of the trunk.

To the present report Mr. J. T. Cunningham contributes a paper on this subject, dealing specially with the plaice and the cod. He describes the structure and formation of the ear-bones and scales, and the mode in which the lines or zones are produced. One of the chief objects of the observations was to test the question how far the lines of growth in the skeletal structures of fishes were trustworthy indications of age—whether the annual increments of growth or deposit could be definitely distinguished and counted in all cases. He shows that it is often necessary to test the indications of one structure by an examination of the others, though in many instances the age of the fish may be well determined by the examination of one of them alone.

The result in regard to the two species mentioned is to show generally that they do not grow so fast or reach maturity so soon as is commonly supposed. It was found that cod at two years of age measure from ten to thirteen or fourteen inches in length, at three years from seventeen to nineteen, and at four years about twenty-seven inches, so that they would spawn as a rule in their fifth year. Plaice from two-and-a-half to about four inches were one year old, from about four to six-and-a-half inches they were two years old, while those at three years measured up to 12 inches.

At 13 and 14 inches they were mostly four years of age, while some in which the lines of growth indicated five years measured $11\frac{1}{2}$, $14\frac{3}{4}$, and $18\frac{3}{4}$ inches, and one measuring 20 inches was shown to be four years old.

The paper is illustrated by three plates showing the otoliths, scales, and bones.

THE LIFE-HISTORY OF THE LOBSTER.

In the present report will be found a paper, illustrated by four plates, in which Dr. H. C. Williamson gives the results of his observations on the life-history of the lobster. An account is furnished of the experiments on lobster-culture which were made at the hatchery, the "berried" or egg-bearing females being kept in a suitable tank, the larvæ as they hatched being carried away in the overflow to receptacles where they were retained. Hatching was found to take place during the night, and the first young lobsters were observed on 11th July.

The larval and early young stages which were reared at the Laboratory are described and figured in detail. Certain dimorphic forms of the zoëa were discovered among the larvæ, and they attracted attention, since, so far as known, such forms have not hitherto been recorded and described. Attention was directed to the behaviour of the lobsters during the time they were kept in confinement at the Laboratory, that is to say, three years in certain cases. Among them only one was known to have spawned its eggs. Casting occurred frequently, more frequently apparently than normally occurs with lobsters in the sea, and the increase in size immediately after moulting was found to be very small; reproduction, moreover, seemed to be inhibited.

Various observations made on the condition of the ovary, the periods of spawning and hatching, the number of eggs carried by the female, the growth of the lobster, and on other points connected with its life-history and habits, are incorporated in the paper.

Dr. Williamson also furnishes a further note on the life-history of the edible crab, treating specially of the hatching of the young.

THE PARASITES OF FISHES.

Dr. Thomas Scott, who is still prosecuting his researches on the parasites of fishes, contributes a paper on these organisms to the present report, in which several species not previously recorded from the Scottish seas are described, the descriptions being illustrated by a number of figures. This paper contains descriptions of seventeen species, twelve of which belong to the Crustacea and five to the Trematoda.

One of the crustacean species described is found living in the nasal fossæ of several kinds of fishes, as the cod, haddock, whiting, &c. Another was obtained in the mouth of a three-bearded rockling, and others on a sturgeon, a porbeagle shark, and other fishes.

The Trematoda, which are leach-like in form, were obtained on the gills of the grey gurnard, the ballan wrasse, and the bass (*Labrax lupus*).

THE MARINE CRUSTACEA.

A paper, illustrated by four plates, is also contributed to the present report by Dr. Thomas Scott on a number of marine crustacea, obtained in collections made during various fishery investigations, especially the trawling investigations in the Moray Firth.

All the forms described are small; they are for the most part free-swimming in their habits and belong to the Copepoda, a group that constitutes a large proportion of the food of the edible fishes in their young stages. Of these free-swimming crustaceans four are new to science and are now described for the first time. A few species that live as parasites on other crustaceans are also recorded. They belong to the somewhat abnormal Choniostomatidæ; two of these are also new to science and are now described for the first time in this report.

THE TAY SPRAT FISHERY.

A paper is included in the present report in which Mr. John Fletcher gives an account of the bag-net fishing for sprats on the Tay in the season 1904-1905. The methods and course of the fishing and the situation of the ground where the sprats are taken are described, but the chief part of the paper deals with the composition of the catches. In forty-six samples examined at various periods from October to February inclusive, comprising 43,871 fishes, the number of young herrings was found to be 26,037, the sprats numbering 16,992; there were also 581 specimens of other food fishes, mostly whiting and cod, as well as 261 specimens of unmarketable and inedible forms. The herrings measured from $1\frac{3}{4}$ inches to 7 inches in length.

The quantity examined represented about one-thousandth part of the entire season's catch. On the basis mentioned tables are given showing the estimated composition of the catches throughout the season, from which it appears that in the 1348 crans taken the number of young herrings was approximately nearly $23\frac{1}{2}$ millions, while the sprats numbered a little over 21 millions. The percentage proportion of herrings increased gradually and steadily from the commencement of the season in October, when it was 20·4, to January, when it was 78·2.

THE YOUNG OF THE CONGER.

In last year's report two specimens of the young of the conger (*Leptocephalus*) at different stages were described, the earlier being known as *Leptocephalus Morrisii* and the older as *L. punctatus*, and both were taken in the Moray Firth. Last May another specimen of *L. punctatus* was captured in Aberdeen Bay in from four to five fathoms of water and brought alive to the Laboratory, as well as the head part of a third specimen. They are described by Dr. Fulton in the present report. *Leptocephali* are exceedingly rare, and the capture of four in so short a time is of interest.

THE SPAWNING OF THE COD IN AUTUMN IN THE NORTH SEA.

Dr. Fulton also describes further observations in connection with the discovery that shoals of cod spawn in August, September, and

October on certain grounds lying off the coast of Norway, and about 190 miles N. by E. of Aberdeen. The previous description appeared in the bulletin (*Publications de Circonstance*) of the International Council for the Exploration of the Sea. The fact that the cod, whose great spawning-time, as is well known, is in spring, should also spawn in autumn is of interest. It has been shown, moreover, that the temperature of the water at the grounds referred to when spawning occurs is the lowest for the year.

INVESTIGATION ON THE HERRING IN THE FIRTH OF CLYDE.

In connection with the winter herring fishing at Ballantrae Bank, off the coast of Ayr, arrangements were made for an investigation of the conditions of the fishing in relation to the operation of the Bye-law, No. 18, by which the use of the seine for the capture of herrings within a defined area there is prohibited. No fishing however took place last year. Only one trial was made by a single boat, and the catch was only about seven hundred small herrings. The "appearances" of herrings were not favourable, and the market prices, as given in the newspapers, were so low that the men did not think it worth while to start the fishing and give up the cod-net and line fishing. That there were herrings on the Bank was shown by their presence in the stomachs of cod and saithe, as reported by the Fishery Officer, and by the coating of herring spawn on the cod nets.

An investigation is also being made on the herrings in other parts of the Firth of Clyde, more especially in Lochfyne, where monthly observations are made on the temperatures, the abundance of herring-food, &c., and marking experiments have been instituted to determine, if possible, the migratory movements of the herrings.

GENERAL INDEX TO THE SCIENTIFIC REPORTS.

A paper, prepared by Dr. Fulton, is given in the present report, embodying a general index to the scientific reports of the Board since the commencement of scientific investigations in 1882. The reports are twenty-two in number, and as they embrace a great variety of subjects connected with the sea fisheries in their scientific aspects, it is hoped the index may be useful to those engaged or interested in fishery investigations.

We have the honour to be,

Your Lordship's most obedient Servants,

ANGUS SUTHERLAND, *Chairman.*

D. CRAWFORD, *Deputy-Chairman.*

D'ARCY W. THOMPSON.

W. R. DUGUID.

L. MILLOY.

D. MEARNS.

H. WATSON.

WM. C. ROBERTSON, *Secretary.*

SCIENTIFIC REPORTS.

I.—TRAWLING INVESTIGATIONS. By Dr. T. WEMYSS FULTON,
F.R.S.E., Superintendent of Scientific Investigations.

INTRODUCTORY.

The investigations into the condition of the fishing grounds in certain parts of the closed waters, particularly in the Moray Firth and Aberdeen Bay, which were begun a few years ago by the employment of commercial steam trawlers, were continued last year as frequently as circumstances allowed. Trawlings were made in January, March, April, September, October, November, and December, the total number of recorded hauls in the closed waters amounting to 91, of which 14 were made in Aberdeen Bay, 75 in the Moray Firth, and 2 in Sandside Bay, on the north coast of Scotland. The localities in the Moray Firth which were most thoroughly examined were Burghead Bay and adjoining parts of the south coast, the Dornoch Firth, and the grounds off the coast of Caithness. A few hauls were also taken on Smith Bank, and in the deeper parts of the Firth, at the so-called "witch-grounds."

The aggregate number of fishes taken in the course of these trawlings, so far as they were completely recorded, was 63,525, and of these 44,538 were taken to market, the remaining 18,987 being thrown overboard, either because they belonged to species which are not edible, or, more commonly, because they were too small to be marketable. The proportions of the marketable and unmarketable in each of the recorded hauls are given in the Tables appended.

Records were also made of a number of hauls of a steam trawler which fished at the Farøes in the month of May, and these are likewise included in the Tables.

One of the chief objects of these trawling investigations is to ascertain as far as possible the changes which may occur in the abundance of the food and other fishes in the closed waters in different years and at different seasons, but observations are also made on the reproduction of the fish, their spawning, food, &c., and on various other matters connected with their life-history, while at the same time records are made of the surface and bottom temperatures of the water on the various grounds visited. The employment of commercial vessels for this purpose is associated with certain disadvantages; but from the fact that the actual trawling work is carried on precisely as it is when fishing for market purposes, opportunities are afforded for a number of observations bearing on this method of fishing, as, for example, the proportion of the marketable and unmarketable fishes which are captured, the relation between the size of the fishes taken and the size of the meshes of the net, the vitality of the fishes, &c. Collections are also made of the floating organisms, or plankton, and of fish eggs and larvæ, and experiments conducted with small-meshed nets with the view of procuring collections of fishes of various sizes in connection with the study of their rate of growth, distribution, &c.

With the large commercial trawl, the efficient ship, and the experienced trawlers in charge, it is possible to make a much more thorough and extensive examination of the grounds than was previously possible.

The work has been sometimes carried on under difficulty, inasmuch as since the reduction of the Vote for Scientific Investigations, when the International researches were initiated, no assistance was available, and it was impossible for me alone to conduct these experiments with the regularity that was desirable. In autumn of last year, Dr. H. C. Williamson was re-appointed to the scientific staff of the Board, and I have to thank that gentleman for his assistance in these investigations.

I.

The first of the series of investigations in Aberdeen Bay and the Moray Firth was made in January, from the 14th to the 23rd, the steam trawler "Ern" being employed, one of the objects being to obtain a supply of large living plaice for the hatchery at the Bay of Nigg. Besides Aberdeen Bay, the places visited were the grounds off the Ord of Caithness and Lybster, Dunnet Bay, and Sandside Bay, these two being situated on the north coast. Three hauls were made in Aberdeen Bay on the 14th, a strong wind blowing from the south-west with rain. The first was in from 5 to 20 fathoms, off Newburgh, for four hours and five minutes, and the catch was small, comprising 387 fishes, of which 360 were marketable and 27 unmarketable. Haddocks and codling formed the bulk of the catch, there being few plaice, and they were all small. The other two hauls were also taken off Newburgh, in from 4½ to 9 fathoms, and they were still less productive, the respective totals being 218 and 293 fishes, the hauls lasting for four hours and four hours and five minutes. Plaice were again very scarce, and haddocks were not numerous, but a considerable number of codling were taken. Among the fishes in the second haul were 14 herrings and 22 sprats. In the three hauls, lasting for twelve hours and ten minutes, 898 fishes were taken, of which 783 were marketable and 115 unmarketable. The numbers of marketable and unmarketable of the various species were as follows:—

	Cod.	Codling.	Haddock.	Whiting.	Plaice.
I.	5	186	431	.	71
II.	.	12	19	27	.
Total	5	198	512	27	71
	Com. Dab.	Long Rough Dab.	Sprat.	Herring.	Starry Ray.
I.	28	.	.	.	.
II.	1	4	22	14	16
Total	29	4	22	14	16

While all the plaice were marketable, there were none of medium size, and none large; all were small. The majority of the haddocks, on the other hand, were large or medium, viz., 330 large, 109 mediums, and 54 small or thirds.

In the Moray Firth the first haul was made on the 17th, off Lybster, in about 25 fathoms, a strong breeze blowing from the south-west. The number of fishes obtained in the four hours' drag was 352, of which 206 were marketable and 146 unmarketable. The catch comprised 20 cod, 146 haddocks, and 128 plaice; all the haddocks except 46 small were unmarketable, and most of the plaice were also small. The next haul was made in rather deeper water, 34 to 36 fathoms, a little farther off, and a rather better catch was got, viz., 522 fishes, of which 330 were marketable. Haddocks and plaice were again most numerous—315 and 162 respectively—and they were, as a rule, larger, especially the plaice, 112 being either large or medium. Other seven drags were taken off Lybster in from 23 to 35 fathoms, with as a rule, poor results, though the weather had improved and the sea was smooth. Omitting one of these, in which the net was split and only 108 fishes secured, the total number of fishes caught in the thirty-three hours and ten minutes fishing was 3478, of which 2005 were marketable and 1473 unmarketable. The largest total number taken in any one haul was 522; the largest number marketable in any haul was 330, and the lowest 118. Haddocks and plaice formed the bulk of the fish caught, the former numbered 1898, of which rather more than half were marketable; the latter numbered 875, all of which were marketable. The total of the marketable haddocks and plaice according to size was as follows:—

	1st	2nd	3rd	4th	Total
Haddock	63	80	46	780	969
Plaice	118	387	342	28	875

The accompanying Table gives the particulars of the marketable and unmarketable fishes of the eight hauls:—

	Cod.	Codling.	Haddock.	Whiting.	Coal-fish.	Cat-fish.	Brill.	Plaice.
I.	29	67	969	.	2	2	2	875
II.	-	58	929	204	-	.	-	-
Total	29	125	1,898	204	2	2	2	875

	Lemon Dab.	Witch.	Common Dab.	Long Rough Dab.	Herring.	Starry Ray.	Skate.	Angler.
I.	39	2	-	-	.	3	12	3
II.	-	-	254	7	1	-	11	9
Total	39	2	254	7	1	3	23	12

On the 18th, owing to the comparatively poor catches on the grounds off Lybster, the vessel left for the north coast to try Sandside Bay, but the wind in the Pentland Firth was so strong that it was forced to return. On the following night Sandside Bay was reached and three

hauls were made there. The first was imperfect, being a "foul" shot, owing to a turn in the net, and only 127 marketable fishes were secured, mostly plaice and haddocks; the depth was from about 40 to 43 fathoms. In the next haul on the same ground, in 40 to 43 fathoms, lasting four hours and five minutes, 324 fishes were taken—169 being marketable and 155 unmarketable. Most consisted of haddocks and plaice; there were also 14 gurnards and 31 dog-fishes. A third haul for four hours and ten minutes, in from 28 to 40 fathoms, was still less productive, the total being 250 fishes, 175 being marketable and 75 unmarketable. The numbers of haddocks and plaice of the various classes according to size, in the two hauls were these:—

	1st	2nd	3rd	4th	Total
Haddock	5	56	10	62	133
Plaice	20	46	46	—	112

The following Table gives the marketable and unmarketable fishes caught in the two hauls, the time of fishing being 8 hours and 15 minutes:

	Cod.	Codling.	Haddock.	Whiting.	Gurnard.
I.	2	4	133	-	-
II.	-	9	112	32	30
Total	2	13	245	32	30
	Plaice.	Lemon Dab.	Common Dab.	Skate.	Dog-fish.
I.	112	58	35	-	-
II.	-	-	-	16	31
Total	112	58	35	16	31

Dunnet Bay was then tried, and a haul taken in 30 to 36 fathoms. After towing for an hour and three-quarters the net caught, and on being brought up it was found that the ground rope was broken, and a good deal of the net missing; what was left contained five marketable fishes.

The vessel accordingly returned to the Moray Firth and started fishing south of Lybster, on the grounds off the Ord of Caithness. The wind was still from the south-west and very squally. The first haul, for 4½ hours, was made in 23 and 24 fathoms, and 405 fishes were secured, of which 170 were marketable and 235 unmarketable. Among the former were 19 cod, 107 haddocks, and 78 plaice, as well as some lemon dabs and common dabs. The second haul for the same time on the same ground, in 23 to 25 fathoms, was slightly better, 446 fishes being taken—169 marketable and 277 unmarketable. Haddocks, plaice, and dabs were the chief fish represented. Other six hauls were taken on this ground, the catches being under those described, and in one of the hauls the trawl net was practically destroyed, nothing coming up but the ground rope. In the seven hauls, the duration of which was 29 hours and 35 minutes,

the aggregate number of fishes caught was only 2086—895 being marketable and 1191 unmarketable—which was extremely poor fishing. The numbers of haddocks and plaice of the various sizes taken in the hauls were as follows :—

	1st	2nd	3rd	4th	Total
Haddock	57	164	65	—	286
Plaice	91	186	192	18	487

The particulars as to the marketable and unmarketable in the seven drags are these :—

	Cod.	Codling.	Haddock.	Whiting.	Coal-fish.	Cat-fish.	Conger-Eel.
I.	36	38	286	.	4	3	2
II.	.	29	478	72	.	.	.
Total	36	67	764	72	4	3	2

	Plaice.	Lemon Dab.	Common Dab.	Long Rough Dab.	Skate.	Angler.
I.	487	33	.	.	16	.
II.	.	.	439	129	11	33
Total	487	33	439	129	27	33

The vessel then steamed to the so-called “witch-grounds,” off Kinnaird Head, and made two drags there on the 23rd. Owing to want of time the unmarketable fishes in these drags, which were very numerous, were not recorded. In the first, for four hours and fifteen minutes, in from 40 to 45 fathoms, 168 marketable fishes were obtained, chiefly haddocks and witches; the offal, or unmarketable fishes, filled seven baskets, the contents of one of which were counted, viz., 306 dabs, 183 long rough dabs, 94 haddocks, and 42 whittings. In the second drag, in from 40 to 50 fathoms, 163 marketable fishes were secured, comprising 4 cod, 7 codlings, 62 witches, and 90 haddocks; the offal or unmarketable fishes filled three baskets, and were not enumerated. Small haddocks, too small to be marketable, were numerous in this locality; the numbers of the various classes of marketable haddocks were, 1st 35, 2nd 65, 3rd 68.

Another haul for an hour and ten minutes was made here in about 50 fathoms with the small-meshed net laced around the cod-end, in order to catch the small fishes, as described in previous reports; 2812 fishes were taken, belonging to 18 species, as follow :—

Cod, - - - -	7	Witch, - - - -	39
Haddock, - - -	249	Lemon Dab. - - -	3
Whiting, - - -	122	Common Dab, - - -	986
Poorcod, - - -	7	Long Rough Dab, -	1048
Norway Pout, - -	250	Herring, - - - -	2
Three-Bearded Rockling,	2	Sprat, - - - -	3
Four-Bearded Rockling,	5	<i>Lumpenus</i> , - - -	65
Grey Gurnard, - -	2	Spotted Dragonet -	15
Plaice, - - - -	4	Hagfish, - - - -	3

The quantity of fish landed at the end of the voyage, according to the market returns, amounted to 99 cwt., as follows :—

Cod.	Codling.	Ling.	Saithe.	Hake.	Haddock.	Whiting.	Turbot.	Halibut.	Brill.
23	4	1	2½	½	16½	¼	½	¼	⅝
	Lemon Dab.	Plaice.	Witch.	Megrim.	Conger.	Skate.	Cat-fish.		
	3½	27	6¼	¼	¼	3	½		

II.

The second series of trawlings was made at the end of March and the beginning of April, the steam trawler "Star of the Wave" being employed. The first place visited was Burghhead Bay, where several hauls were taken, in from 4 to 16 fathoms, on 28th and 29th. In the first, which was carried into water of 30 fathoms depth, 1202 fishes were taken—780 being marketable and 422 unmarketable. The fishes most abundantly represented were common dabs, plaice, haddocks, and witches; there were also 24 brill and 19 lemon dabs, all marketable, as well as 5 herrings. All the haddocks and most of the plaice were small. The next three hauls were made nearer the shore, in water of from about 4 to 16 fathoms. In the first of these 975 were secured—574 being marketable and 401 unmarketable. Common dabs and plaice were best represented, numbering respectively 360 and 325—90 of the dabs and 302 of the plaice being marketable. The catch also included 89 haddocks—all small, and 37 marketable—6 catfish, 20 lemon dabs, and 35 witches. The second haul brought up 698 fishes, mostly plaice and dabs, the marketable fishes including 23 brill, 2 turbot, 10 lemon dabs, and 9 witches, as well as 18 haddocks, 3 cod, and 2 catfishes. The third haul, for five hours and twenty-six minutes, yielded 2331 fishes, of which 1181 were marketable and 1150 unmarketable. The catch included 1116 common dabs, 576 plaice, 208 haddocks, 30 lemon dabs, 13 brill, and 2 turbot; there were also in this haul 28 anglers, 8 herring, and a lumpsucker.

The aggregate number of fishes in the three inshore drags referred to was 4004, 2168 being marketable and 1836 unmarketable. The numbers of haddocks and plaice of the various classes according to size were as follows :—

	1st	2nd	3rd	4th	Total
Haddock	16	—	204	—	220
Plaice	96	276	416	335	1123

The details of the four hauls referred to are summed up in the accompanying Table :—

	Cod.	Codling.	Haddock.	Whiting.	Coalfish.	Catfish.	Gurnard.	Turbot.	Brill.	Flounder.
I.	8	19	440	220	2	17	11	4	100	-
II.	.	27	99	53	.	.	8	.	-	9
Total	8	46	539	273	2	17	19	4	100	9

[Continued.]

	Plaice.	Lemon Dab.	Witch.	Com. Dab.	Long Rough Dab.	Thorn-back.	Herring.	Angler.	Lump-sucker.
I.	1,345	79	141	483	.	69	.	30	.
II.	95	2	60	1,630	198	16	13	25	3
Total	1,440	81	201	2,113	198	85	13	55	3

Some other hauls were made in this district, but in somewhat deeper water. In the first of these off Burchhead, in 44 to 45 fathoms, and lasting four hours and twenty minutes, 1638 fishes were captured, 1280 being marketable and 358 unmarketable. The number of haddocks increased to 817, most of them being small; plaice diminished to twenty, mostly large and medium; there were also 269 witches, 106 lemon dabs, a megrim, a brill, and 8 cod. In the next haul, lasting three hours and thirty-five minutes, in the same depth, 4030 fishes were obtained, 2483 being marketable and 1547 unmarketable; nineteen species were represented. Haddocks were most abundant, numbering 1927; there were 1358 dabs, 282 witches, 251 whiting, 27 lemon dabs, and 10 plaice. Ten Norway pouts, a herring, a bib, and 2 Lumpenus were also taken, as well as 5 marketable hake. The next haul was begun in the same place, the vessel towing towards Lossiemouth, where the net was hauled in 16 fathoms. The drag lasted for two hours and twenty-five minutes, and 1427 fishes were taken, comprising 837 haddocks, 139 whittings, 40 plaice, 51 lemon dabs, 6 witches, as well as 4 cod, 2 ling, and a Norway pout.

In these three hauls in deeper water the total number of fishes caught was 7095, 4846 being marketable and 2249 unmarketable, the time of fishing being ten hours and twenty minutes. The sizes of the haddock and plaice taken were as follows:—

	1st	2nd	3rd	4th	Total
Haddock	235	154	3113	—	3502
Plaice	17	44	14	—	75

The particulars are given in the following Table:—

	Cod.	Cod-ling.	Hake.	Ling.	Haddock.	Whiting.	Gurnard.	Brill.	Plaice.	Lemon Dab.	Witch.
I.	19	10	22	2	3,502	530	17	5	75	176	429
II.	-	5	.	.	79	12	8	-	-	8	128
Total	19	15	22	2	3,581	542	25	5	75	184	557

	Megrim.	Com. Dab.	Long Rough Dab.	Thorn-back.	Grey Skate.	Angler.	Norway Pout.	Herring.	Bib.	Lumpenus.
I.	2	47	-	-	-	10	.	-	-	-
II.	-	257	1,720	10	2	5	11	1	1	2
Total	2	304	1,720	10	2	15	11	1	1	2

A haul for four hours was made in thirteen fathoms off Lossiemouth, the vessel trawling around a dan, but the catch was very poor, the number of marketable fishes secured being 191, and the unmarketable 79, a total of 270. There were 107 plaice, 36 haddocks, eight brill, a cod, a catfish, and a lumpsucker in the catch.

The next place visited was the Dornoch Firth. On 30th March the trawl was dropped in sixteen fathoms, with Dunrobin Castle bearing N.W. and Tarbert Lighthouse about S. $\frac{1}{2}$ E.; a sweep was made around the bay into four fathoms and out again, the haul lasting for four hours. The weather was fine and the sea smooth.

In the hauls made here a special cod-end with large meshes was used, and the catches, especially of the unmarketable fishes, were therefore smaller than would have been the case otherwise; the records cannot thus in this respect be compared with the foregoing.

The catch consisted of 400 fishes, of which 354 were marketable. The plaice numbered 138, and there were 69 cod and 123 flounders. In the next haul, in the same locality, 210 fishes were taken, the catch comprising 43 cod, 87 plaice, 38 flounders and 29 skates and rays. Other four drags were made here, and the aggregate catch for the six hauls, comprising twenty-four hours and five minutes fishing, was 1932 fish, 1837 being marketable.

The details of the catches are given in the adjoining Table; what is stated above as to the mesh of the cod-end must be borne in mind.

	Cod.	Codling.	Coal-fish.	Haddock.	Cat-fish.	Brill.	Plaice.	Lemon Dab.
I.	754	5	9	35	12	4	581	33
II.	.	1	.	.	.	.	6	.
Total	754	6	9	35	12	4	587	33

	Witch.	Flounder.	Common Dab.	Long Rough Dab.	Thorn-back.	Sprat.	Grey Skate.
I.	15	235	57	.	92	.	5
II.	.	32	17	3	11	2	23
Total	15	267	74	3	103	2	28

Large and medium-sized haddocks were present in the catches, the numbers taken being—large 86, medium 80, small 130, fourths, 152; many of the smaller haddocks would escape through the mesh of the cod-end used.

The fishing in the Dornoch Firth on this occasion was of special interest, for several reasons. Cod were taken in quite unusual numbers, a shoal of spawning fish having been hit upon, and each haul of the net was characterised by the large number of cod present. On hauling the net, the cod-end, in which the fish were contained, could be seen floating at the surface some distance away from the vessel; this is always the case with large catches of the greater round fishes. The greatest number of cod caught in one haul of four hours was 282, but in each drag the net contained many scores. Owing to the weight of fish

the cod-end was not brought in to the deck at first in the ordinary way, but a hole was cut in it as it lay alongside the vessel and the cod removed by a "clip" and passed along to the fish-hold; then the net was brought aboard. As mentioned, the cod were all spawning, eggs and milt flowing freely from them, and I was struck with their large size. There were no small cod among them. It was not possible to measure them all, but the smallest and the larger were put aside and measured. The smaller female fishes ranged from 33 to 35 inches; two males measured $29\frac{1}{4}$ and 30 inches; among a few "codling" taken I found one measuring $27\frac{1}{2}$ inches, quite immature. Several smaller-sized cod were brought up in a state of decay, and had been lying on the ground dead for some time; whether these had been caught previously by some other trawler, escaped from the net and perished, was unknown. The skipper (S. Caie) stated that at Farøe they sometimes get as many as sixty score of cod (1200) in a single drag of three hours' duration.

Besides the cod, several of the other fishes taken at this place were ripe and spawning. Among the few coalfish caught I found a female, measuring $40\frac{1}{2}$ inches, half spent, with the eggs flowing freely, and several of the males were also mature. Most of the flounders, of which 267 were taken—235 of them marketable—were also spawning, and it is evident from a comparison of the records at other times of the year that shoals of flounders come out from the shallower waters—no doubt largely from the stretch of brackish water west of Gizzing Briggs—at this season in order to spawn. Spawning females were found from ten inches upwards, and spawning males from a size of eight inches. Some plaice were also found ripe and spawning, though the number of this fish taken was relatively small, and still more were spent. Among the common dabs the condition was not so far advanced, most of the larger ones having the reproductive organ large and ripe, and a few were just commencing to spawn.

On this ground, therefore, spawning cod, coalfish, flounders, plaice, and common dabs were found on the 30th and 31st March. It lies about three miles from the nearest land, on the edge of, and partly over, the rough ground that under ordinary circumstances is avoided by trawlers, the depths being from thirteen to fifteen or sixteen fathoms. It is possible, I may say, to fish over the rough ground when cod or other round fishes are present in large numbers, the trawlers explaining that the cod-end, and perhaps most of the net, is buoyed up from the bottom by the fish. The locality lies well within the Dornoch Firth, and I think it will be found that there is some peculiarity about the currents here that tends to distribute the floating eggs, the movement of the water being northwards, rather as an eddy.* From the small number of plaice got it is not certain that they spawn on these grounds in any great numbers, and the same remark may be made about the coalfish. Clearly, however, cod and flounders spawn there in great numbers.

Before leaving the Dornoch Firth a haul was made for half an hour with the small-meshed net around the cod-end, the trawl going into four fathoms. The number of fishes taken was 1107, belonging to ten species, as follows:—

Codling, -	-	-	1	Plaice, -	-	-	74
Haddock, -	-	-	2	Flounder, -	-	-	53
Whiting, -	-	-	27	Common Dab, -	-	-	46
Herring, -	-	-	16	Sprat, -	-	-	870
Little Sole, -	-	-	2	Common Pipefish,	-	-	16

* *Vide* Fulton, "The Currents of the North Sea and their Relation to Fisheries," *Fifteenth Annual Report, Part III.*, p. 343.

The vessel then steamed to the south coast of the Moray Firth and took a haul with the small-meshed net around the cod-end, between Findhorn and Burghead, in 30 to 32 fathoms, the haul lasting for an hour. The total number of fishes obtained was 1753, belonging to eighteen species, as follows :—

Codling,	-	-	10	Plaice,	-	-	1
Coalfish,	-	-	1	Lemon Dab,	-	-	14
Haddock,	-	-	19	Common Dab,	-	-	68
Whiting,	-	-	20	Witch,	-	-	221
Norway Pout,	-	-	387	Long Rough Dab,	-	-	516
Herring,	-	-	36	Megrim,	-	-	1
Sprat,	-	-	74	Flounder,	-	-	4
<i>Lumpenus</i> ,	-	-	365	Thornback,	-	-	1
Dragonet,	-	-	2	Angler,	-	-	13

Smith Bank was then visited, and a haul made there with the small-meshed net for twenty-five minutes (the net catching on the bottom after that interval and being hauled) in 22 fathoms. The number of fishes caught was 1545, belonging to thirteen species, as follows :—

Codling,	-	-	34	Plaice,	-	-	2
Haddock,	-	-	444	Lemon Dab,	-	-	10
Whiting,	-	-	502	Common Dab,	-	-	99
Ling,	-	-	1	Long Rough Dab,	-	-	6
Poorcod,	-	-	436	Catfish,	-	-	3
Norway Pout,	-	-	6	Herring,	-	-	1
Gurnard,	-	-	1				—

Before returning to Aberdeen a haul with the small-meshed net was taken in Aberdeen Bay, in the northern part, but the net came up much torn and no fishes were caught ; there was a heavy sea and a strong wind.

According to the market statistics, the quantity of fish landed amounted to 246 $\frac{3}{8}$ cwts., as follows :—

Cod.	Codling.	Saithe.	Haddock.	Whiting.	Turbot.	Brill.	Lemon Dab.	Plaice.
178 $\frac{1}{2}$	$\frac{5}{4}$	1 $\frac{3}{8}$	17	2 $\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{2}$	2 $\frac{1}{2}$	21 $\frac{1}{2}$
			Dabs.	Witch.	Skate.	Cat-fish.	Monk.	
			2 $\frac{1}{4}$	5 $\frac{1}{4}$	9	3 $\frac{1}{2}$	1	

III.

The next series of trawlings was made at the end of September and the beginning of October, the steam trawler "Star of the Ocean" being employed. The first place visited was the deep hole off Fraserburgh, where a haul was made in 75 fathoms, a dan being put down in 70 fathoms. In sounding, a depth of 130 fathoms was got in the locality, fine dirty sand being on the armature of the lead. The net became fast and it was hauled in two hours in 35 fathoms. The catch comprised 1177 fishes, of which 900 were marketable and 277 un-marketable. Haddocks were best represented, the number taken being 825, but most of them were small. There were also 44 cod and 170 codling, 44 whiting, 11 gurnards, 18 lemon dabs, 11 megrims, and 1 witch, with some other fishes. No plaice or common dabs were caught.

Burghead Bay was then visited and a couple of drags made in from 5 to 12 fathoms. In the first, which lasted for four hours and ten

minutes, 597 fish were caught, 184 being marketable and 413 unmarketable. The catch was made up mainly of small haddocks and plaice, together with common dabs. In the second haul, for four hours and ten minutes, 1339 fishes were secured, of which 556 were marketable and 783 unmarketable. The catch was again chiefly composed of small haddocks. In these two hauls, the time of fishing being eight hours and twenty minutes, 1936 fishes were taken, of which 740 were marketable and 1196 unmarketable. The haddocks numbered 1565, no less than 999 of them being too small to be marketable. The numbers of haddocks of the various classes were these :—

	1st	2nd	3rd	4th	Unmarketable	Total
Haddock	27	48	491	—	999	1565

The plaice were also, as a rule, small, but the separate sizes were not noted.

The details regarding the different species are as follows:—

	Cod-ling.	Haddock.	Whiting.	Gurnard.	Plaice.	Lemon Dab.	Common Dab.	Long Rough Dab.	Thorn-back.	Angler.
I.	4	566	27	.	135	5	127	-	3	-
II.	.	999	16	37	8	-	-	6	-	2
Total	4	1,565	43	37	143	5	127	6	3	2

A number of hauls were then taken between Burghead Bay and Lossiemouth, in water from 7 to 12 fathoms deep. In the first, which lasted for three hours and fifteen minutes, 498 fishes were caught, 287 being marketable and 211 unmarketable. The catch comprised 347 haddocks—nearly half of them too small to be taken to market—and 42 cod. In the second, for four hours and thirty-five minutes, 892 fishes were caught, 458 being marketable and 434 unmarketable. Haddocks again formed the bulk of the catch, numbering 587, of which less than half were marketable, and there were also 145 plaice and seven cod. Most of the other hauls made in this place were less productive, but in one the number was considerably exceeded. It was for four hours and five minutes, and 3157 fishes were captured, of which 972 were marketable and 2185 unmarketable. The catch comprised 1425 haddocks, 879 being too small to go to market; 358 plaice, all but 6 marketable; 1082 common dabs, 201 gurnards (none taken to market), 51 codling, 4 cod, 2 turbot, 8 brill, and 5 lythe or pollack.

In the seven hauls between Burghead and Lossiemouth, the duration of fishing being twenty-eight and a half hours, the total number of fishes caught was 6637, or an average of 2328·9 per ten hours' fishing; the marketable fishes numbered 2880, or an average of 1010·4 per ten hours, the unmarketable numbering 3757, or an average per ten hours of 1318·3. Of 2871 haddocks caught rather more than half, viz., 1474, were unmarketable, while of 1203 plaice only 7 were too small to be taken to market. In one of the hauls 5 lythe were caught, in another 4 coalfish, too small to be marketable; and in another 4 fine black soles, a fish which is very rarely caught in these waters. Of the 1397 haddocks, 96 were large, 204 mediums, and 1097 small or thirds; a classification into thirds and fourths was not adopted on this occasion.

The accompanying Table gives the particulars of the catches of the seven hauls combined.

	Cod.	Codling.	Haddock.	Whiting.	Coalfish.	Lythe.	Gurnard.	Turbot.	Brill.
I.	61	90	1,397	33	-	5	.	4	17
II.	.	21	1,474	46	4	.	589	.	.
Total	61	111	2,871	79	4	5	589	4	17

	Plaice.	Lemon Dab.	Black Sole.	Witch.	Common Dab.	Angler.	Thorn-back.	Wrasse.
I.	1,196	37	4	2	26	-	7	1
II.	7	.	.	.	1,527	86	3	.
Total	1,203	37	4	2	1,553	86	10	1

A haul was also made on the usual ground off Lossiemouth, in 17 fathoms, for one hour and forty-five minutes. The catch consisted of 605 fishes, 405 being marketable and 200 unmarketable, all the latter consisting of gurnards. There were 314 haddocks and 80 plaice; about half of the haddocks were large and mediums, and half small, while all the plaice were large and mediums. In the hauls in Burghhead Bay, and between it and Lossiemouth, several hundred squids and a few edible crabs were taken.

The vessel then steamed to the Dornoch Firth, where a drag with the small-meshed net around the cod-end was made for an hour and five minutes in from 10 to 12 fathoms. The catch of both nets numbered 1035 fishes, of which 697 were marketable, mostly of small haddocks ("thirds"). The numbers of the various species were as follows:—

Codling,	-	-	-	3	Plaice,	-	-	-	12
Haddock,	-	-	-	833	Common Dab,	-	-	-	32
Whiting,	-	-	-	133	Gurnard,	-	-	-	22

Another drag was made here, but the net had a twist on it, and only 133 fishes were caught in the four hours that the haul lasted, 56 being marketable.

The grounds off Lybster were then visited on 3rd October, and a drag taken for four hours and ten minutes in from 26 to 34 fathoms. The catch comprised 991 fishes, 400 being marketable and 591 unmarketable. Haddocks formed the bulk of the catch, numbering 811, of which only 340 were marketable; there were also 60 gurnards, 23 codlings, and 58 lemon dabs, as well as smaller numbers of other species. Two dog-fishes were taken in the net, and also a number of squids.

The next place visited was Smith Bank, where a haul about the middle, in 19 and 20 fathoms, was taken for an hour and ten minutes. The cod-end contained an immense quantity of gurnards, which filled fifteen baskets. One which was counted contained 178 of various sizes, so that on this basis the total number would be about 2670. There

were also in the cod-end 79 haddocks, nearly all small, 13 plaice, and 76 common dabs. The contents of the small-meshed net filled six baskets, one of which contained 348 small haddocks, 93 dabs, 4 whittings, 3 codlings, 103 gurnards, and 4 lemon dabs, so that the total number of small fishes which had passed through the meshes of the cod-end would number about 3300, mostly haddocks and gurnards.

Two hauls were then made in Aberdeen Bay in the neighbourhood of Newburgh, in from 5 to 13 fathoms. In the first, for four hours and ten minutes, 384 fishes were caught, of which 242 were marketable and 142 unmarketable. Haddocks, plaice, whittings, and dabs formed the greater part of the catch, most of the haddocks being unmarketable. In the next drag 572 fishes were obtained, 274 being marketable, 5 of which were turbot. The particulars of these two hauls, the time of fishing being eight hours and fifteen minutes, are as follows :—

	Had-dock.	Whit-ing.	Gur-nard	Turbot.	Plaice.	Lemon Dab.	Common Dab.	Long Rough Dab.	Angler.
I.	41	48	-	5	364	3	55	-	-
II.	103	21	13	-	-	.	298	3	2
Total	144	69	13	5	364	3	353	3	2

The statistics showed that the total quantity of fish landed at the market amounted to 65½ cwts., as follows :—

Cod.	Codling.	Ling.	Hake.	Haddock.	Turbot.	Brill.	Lemon Dab.	Plaice.
14½	3	1½	½	21½	½	¼	¾	18
			Dabs.	Whitch.	Skate.	Cat-fish.		
			½	¼	2	½		

IV.

Early in November another series of hauls was made in Aberdeen Bay by the "Ocean Bride." The first, for three and a quarter hours, was between the "Black Dog" and Newburgh, in 11 to 13 fathoms, and 689 fishes were caught, of which 422 were marketable and 267 unmarketable. Haddocks numbered 185, all but 15 large enough to go to market; there were 73 plaice, 163 common dabs, 9 cod, 63 codling, 154 whiting, as well as a halibut and 3 turbot. Other five recorded hauls were made in the same locality in from 4½ to 13 fathoms, and the total number of fishes taken in the twenty-one hours and forty minutes of actual fishing was 2398, 1410 being marketable and 988 unmarketable. The particulars are given in the following Table :—

	Cod.	Codling.	Had-dock.	Whiting.	Gurnard.	Ling.	Coal-fish.
I.	62	181	685	69	.	1	2
II.	.	9	66	293	9	.	.
Total	62	190	751	362	9	1	2

[Continued.

	Halibut.	Turbot.	Plaice.	Common Dab.	Long Rough Dab.	Skate.	Angler.
I.	2	3	346	59	.	.	.
II.	.	.	.	230	76	293	12
Total	2	3	346	289	76	293	12

V.

The next series of trawling observations was made in the Moray Firth in the latter part of November, the trawler employed being the "Braconhill." Burghhead Bay was first visited, and three hauls were taken there on the 21st and 22nd in from 5 to 15 fathoms. In the first the number of fishes secured in the three hours and fifteen minutes the drag lasted was 462, of which 421 were marketable. The bulk of the catch consisted of plaice, of which 405 were caught, mostly small and mediums. Haddocks were scarce, only 28 being taken, and they were all unmarketable. Seven brill were also included in this catch. In the next haul, for three hours and fifty minutes, 1385 fishes were obtained, 1145 being marketable and 240 unmarketable. The number of plaice was large, viz., 1072, and they were all marketable, chiefly small and mediums. Four turbot and 12 brill were also caught in this drag. The other two hauls on this ground were equally productive, the catches totalling 1307 and 1493 fishes respectively, the greater proportion being marketable, and consisting chiefly of plaice.

The vessel then steamed to the so-called "witch-ground," off Cromarty, and made a haul there in 27 to 30 fathoms for an hour and ten minutes with the small-meshed net around the cod-end; there was a strong breeze from the N.N.E., with snow showers and a rough sea. The number of fishes in the cod-end was 310, of which 67 were marketable; they chiefly consisted of whittings, witches, and dabs. The small-meshed net contained the following fishes:—

Codling, - - -	2	Long Rough Dab, - -	152
Haddock, - - -	17	Common Dab, - - -	94
Whiting, - - -	349	Witch, - - -	21
Norway Pout, - -	83	Gurnards, - - -	4
Hake, - - -	4		

Two other hauls were taken in this locality, the catches of which were not recorded; in the second the net was split and the ground rope broken, and the vessel lay to till morning and then returned to Burghhead Bay, where a series of hauls were made. In the first of these, in from 7 to 19 fathoms, for four hours and a half, 1139 fishes were secured, of which 939 were marketable and 200 unmarketable. The plaice numbered 917, and the haddocks 155, all of the latter except five being too small for market; a turbot and 11 brill were also taken. In the next drag 1049 fishes were taken in the four hours and ten minutes it lasted, almost all marketable, viz., 998, and mostly plaice, which numbered 962. In the third drag, for four hours and fifteen minutes, 1283 fishes were captured, 1199 of which were marketable; and in a fourth haul 1339 were taken, 1262 being marketable, plaice again forming the greater portion of the catch, which also included 7 turbot 18 brill.

The vessel then proceeded to the Dornoch Firth, where three hauls were made. One of these was not recorded, and the first of the others was a small-meshed drag, which lasted for one hour and was made in from 6 to 10 fathoms, a moderate breeze blowing from the W.S.W. with rain, and the sea being smooth. In the cod-end there were 396 fishes, 284 of which were marketable and 112 unmarketable. Most of the catch consisted of plaice, but there were also 57 large and medium haddocks, a cod, and a few dabs. The contents of the small-meshed net were as follows :—

Codling, - - -	26	Long Rough Dab, - -	1
Whiting, - - -	408	Plaice, - - -	30
Common Dab, - -	127	Herring, - - -	573
Witch, - - -	1	Sprat, - - -	79

The second drag, in about 8 fathoms for four hours, gave 1650 fishes, of which 1594 were marketable. The catch included 1252 plaice, 5 cod, 348 haddocks, a halibut, and 2 turbot. The two drags, representing five hours' fishing, yielded 2046 fishes, 1878 being marketable. In this total the plaice numbered 1481 and the haddocks 409. The marketable and unmarketable fishes are as follows :—

	Cod.	Cod-ling.	Had-dock.	Whit-ing.	Coal-fish.	Hali-but.	Tur-bot.	Plaice.	Lemon Dab.	Com. Dab.	Thorn-back.
I.	6	7	389	.	1	1	2	1,457	3	12	.
II.	-	10	20	31	.	.	.	24	.	80	3
Total	6	17	409	31	1	1	2	1,481	3	92	3

Both among the haddocks and the plaice the proportion of the small fishes was inconsiderable compared with some other hauls. The numbers of the different classes were as follows :—

	1st	2nd	3rd	4th	Unmarketable	Total.
Haddock,	223	166	—	—	20	409
Plaice,	4	426	307	720	24	1481

Before leaving the Firth some further hauls were made in Burghead Bay on the 26th. In the first of these, in from 6 to 19 fathoms and for four hours and a half, the number of fishes caught was 1017, 922 being marketable. Haddocks were sparingly represented, the bulk of the catch consisting of plaice—857—and 2 turbot, 17 brill, and 2 witches were also included in the total. In the next haul, in 16 to 20 fathoms, for four hours and twenty minutes, 1013 fishes were taken, 909 being marketable; they consisted mostly of plaice. The third haul was not completely recorded; it included nine baskets of plaice.

In the ten hauls made in Burghead Bay during this trip, the duration of actual fishing being being forty hours and five minutes, the total number of fishes obtained was 11,487, or an average of 2865·6 per ten hours' fishing the marketable numbered 10,038, the average per ten hours being 2504·4, and the unmarketable amounted to 1449, the

average being 361·2. The particulars are given in the accompanying Table:—

	Cod.	Codling.	Haddock.	Whiting.	Coalfish.	Gurnard.	Halibut.	Turbot.	Brill.
I.	19	12	12	-	1	-	3	19	121
II.	-	59	340	160	-	144	-	-	-
Total	19	71	352	160	1	144	3	19	121

	Plaice.	Lemon Dab.	Black Sole.	Witch.	Com. Dab.	Long Rough Dab.	Skate.	Angler.
I.	9,404	20	1	20	378	-	28	-
II.	56	-	-	-	644	10	9	27
Total	9,460	20	1	20	1,022	10	37	27

The number of haddocks, it will be observed, was very small, and the remark is true indeed of round fishes generally. The ten drags yielded only one dozen marketable haddocks, the same number of codlings, while all the whittings were unmarketable. Flat-fishes, on the other hand, were abundant. Nineteen turbot, 121 brill, 3 halibut, and 9404 plaice were taken to market, as well as 20 lemon dabs, a black or common sole, and some others. A considerable proportion of the plaice consisted of mediums, as the following statement shows:—

	1st	2nd	3rd	4th	Unmarketable	Total.
Plaice,	91	4110	5090	113	56	9460

In Aberdeen Bay, on the 28th, a haul was taken with the small-meshed net around the cod-end, in 19 to 21 fathoms, the drag lasting for one hour and fifteen minutes. The catch was a very poor one, consisting of only 18 marketable fishes and 61 unmarketable, in the cod-end, or 79 altogether, and it comprised 30 haddocks and 31 whittings, and only 6 plaice. The small-meshed net contained the following:—

Codling,	-	-	48	Common Dabs,	-	53
Haddock,	-	-	46	Long Rough Dabs,	-	11
Whiting,	-	-	806	Herring,	-	1
				Sprats,	-	6

The total quantity of fish landed as a result of this trip amounted to 183 $\frac{3}{8}$ cwts., as follows:—

Cod.	Codling.	Haddock.	Turbot.	Halibut.	Brill.	Lemon Dab.	Plaice.	Dabs.
9 $\frac{3}{4}$	1 $\frac{1}{2}$	6 $\frac{1}{2}$	1 $\frac{1}{2}$	$\frac{1}{2}$	4		146 $\frac{1}{2}$	3 $\frac{3}{4}$
			Witch.	Conger	Skate.			
			3 $\frac{1}{2}$	$\frac{1}{2}$	5			

VI.

In the early part of December another series of trawlings was made, the steam trawler employed being the "Loch Lydoch." In the Moray Firth Burghead Bay was the first place visited. A haul there on the 6th, in from 16 to 4½ fathoms, but chiefly under 7, for four hours, gave 1007 fishes, of which 849 were marketable and 158 unmarketable. Plaice formed the bulk of the catch; 747 were obtained, all but 9 being marketable. There were also 8 cod, 4 turbot, 21 brill, and 3 lemon dabs. Only 20 haddocks were taken, and they were all unmarketable. The plaice amounted to nine level basketfuls, five consisting of mediums, one of large, and the rest thirds. The weather was fine, the sea calm, with a gentle westerly breeze.

The second drag, for four-and-a-quarter hours, was made in the same place and in the same depths, and the catch amounted to 1082 fishes, 939 being marketable and 142 unmarketable. The number of plaice caught was 853, all being marketable; 11 were large, 291 medium, and 551 small. Included in the catch were 18 cod, 2 turbot, 13 brill, and a cat-fish. Haddocks were very scarce, only seven being taken, one of which was marketable. In the same locality the third drag, for four hours and ten minutes, in from six to nine fathoms, yielded 1120 fishes, of which 950 were marketable and 170 unmarketable. There were 860 plaice, all marketable, twelve being large, 318 medium, and 530 small. There were also ten brill, twelve cod, and thirty-two haddocks, of which only six were marketable.

The next haul extended into deeper water, viz., twenty fathoms, but was mostly about eight or nine, and in the four hours and five minutes it lasted 953 fishes were taken, of which 897 were marketable and 56 unmarketable. The catch included 823 plaice, all marketable, two turbot, nineteen brill, a cod, and a few dabs. There were twenty-one haddocks, all unmarketable.

A drag for an hour with the small-meshed net around the cod-end of the trawl yielded in the latter 208 fishes, plaice again predominating.

The small-meshed net contained 329 fishes, as follows:—

Codling, - - -	8	Sand-eel, - - -	6
Whiting, - - -	134	Herrings, - - -	129
Common Dab, - - -	18	Sprats, - - -	23
Long Rough Dab, - -	1		

The vessel then steamed to the Dornoch Firth, where a few hauls were made. The first, with the small-meshed net around the cod-end, lasted for an hour, and was made in from 4 to 9 fathoms. The number of fish taken was 213—178 being marketable and 35 unmarketable. The catch included 1 cod, 3 codling, 18 haddocks, all marketable, 156 plaice, and a few others.

A few other hauls were made around a dan, placed in 12 fathoms. In the first of these, the drag lasting four hours and twenty minutes, 934 fishes were secured, of which 811 were marketable. The catch included 737 plaice, 55 of which were unmarketable, and 117 haddocks, all but ten of which were marketable. The next haul was not completely recorded; it included two baskets of medium and one of small plaice, one basket of large and one of small haddocks. Another drag made in from 8 to 12 fathoms, and lasting for five hours, yielded 850 fishes, 742 being marketable and 108 unmarketable. Plaice formed the bulk of the catch, 746 being taken, of which 33 were unmarketable; only 7 haddocks

were taken in this drag, all marketable. In the three recorded hauls, the duration of fishing being ten hours and twenty minutes, 1999 fishes were caught, 1733 being marketable and 266 unmarketable. The proportion of large and small haddocks and plaice was as follows:—

	1st	2nd	3rd	4th	Unmarketable	Total
Haddocks,	4	18	110	—	10	142
Plaice,	—	406	498	640	95	1639

The details as to the marketable and unmarketable are these:—

	Cod.	Cod-ling.	Had-dock.	Whit-ing.	Gur-nard.	Plaice.	Lemon Dab.	Meg-rim.	Com. Dab.	Sole-nette.	Thorn-back.
I.	3	5	132	1	-	1,544	1	1	35	-	9
II.	-	26	10	25	3	95	-	-	88	1	18
Total	3	31	142	26	3	1,639	1	1	125	1	27

Some further drags were made in Burghhead Bay with, on the whole, good catches of fish. The depth was usually from 6 to 9 fathoms, the length of the haul about four hours, and the aggregate number of fishes for a haul varied from 631 to 1027. Plaice formed the greater part of the catches, but there were also a good few cod, turbot, and brill, while haddocks remained singularly scarce. The aggregate numbers in the eleven recorded hauls here during the voyage—the duration of the fishing being forty-two hours and twenty minutes—were 9253 fishes, 8032 marketable and 1221 unmarketable. The following Table shows the proportion of marketable and unmarketable of each kind:—

	Cod.	Codling.	Had-dock.	Whit-ing.	Cat-fish.	Gur-nard.	Coal-fish.	Halibut.
I.	71	37	42	-	1	-	1	1
II.	-	172	137	148	-	15	-	-
Total	71	209	179	148	1	15	1	1

	Turbot.	Brill.	Plaice.	Lemon Dab.	Witch.	Common Dab.	Long Rough Dab.	Flounder.
I.	15	136	7,530	8	17	530	-	2
II.	-	-	50	1	-	623	32	-
Total	15	136	7,580	9	17	1,153	32	2

	Thorn-back.	Sandy Ray.	Sand Eel.	Sprat.	Angler.	Cottus Scorpius.	Herring.
I.	-	1	-	-	-	-	-
II.	6	16	1	1	41	1	11
Total	6	17	1	1	41	1	11

It will be observed that only 179 haddocks were taken, and of these only 42 were marketable, or a proportion of about one haddock per hour's fishing. None of the 148 whittings caught were marketable, while 37 out of 209 codlings were marketable. There were 15 turbot and 136 brill, all of them being marketable. The bulk of the marketable fishes consisted of plaice, of which altogether 7580 were taken, all but 50 being marketable. The proportion of large and small among the plaice was as follows :—

1st	2nd	3rd	4th	Unmarketable	Total
62	3222	3854	394	50	7580

The vessel then steamed to Smith Bank, where a haul was made for an hour with the small-meshed net around the cod-end in from 19 to 22 fathoms. In the trawl-net there were only 28 fishes, viz., a codling, a brill, and 26 plaice, all marketable. The small-meshed net contained 1968 fishes, belonging to ten species, as follows :—

Codlings, - - -	53	Sand-eel, - - -	1
Haddock, - - -	4	Armed Bullhead - -	1
Whiting, - - -	1861	<i>Liparis</i> , - - -	3
Gurnard, - - -	2	Herring, - - -	12
Common Dab, - -	27	Sprat, - - -	4

On the way to port a few hauls were taken in Aberdeen Bay, a strong N.E. wind blowing, with a rough sea and heavy rain. The first drag was for an hour, in from 17 to 19 fathoms, in the northern part, off the quarries, and the small-meshed net was used. The trawl contained 143 fishes, of which 103 were marketable. The catch comprised 6 cod, 54 codling, all marketable, 41 plaice, and a few others. In the next drag in the same locality, for four hours and five minutes, in from 17 to 19 fathoms, 182 fishes were caught, of which 136 were marketable and 46 unmarketable. Among the former were 19 cod, 24 codling, 2 halibuts, and 78 plaice. In neither haul were any haddocks taken.

The following Table shows the proportion of the marketable and unmarketable fishes :—

	Cod.	Cod-ling.	Whit-ing.	Hali-but.	Plaice.	Com. Dab.	Long Rough Dab.	Thorn-back.	Grey Skate.	Ang-ler.
I.	25	78	-	2	119	12	-	-	2	1
II.	-	5	10	-	-	24	10	33	4	-
Total	25	83	10	2	119	36	10	33	6	1

The total quantity of fish landed by this vessel, as a result of its trip, amounted to 118 $\frac{7}{8}$ cwts., as follows :—

Cod.	Codling.	Haddock.	Turbot.	Halibut.	Brill.	Lemon Dab.
16 $\frac{5}{8}$	3	4	1	$\frac{1}{4}$	3	$\frac{3}{8}$
		Plaice.	Dabs.	Skate.	Catfish.	
		86 $\frac{3}{4}$	3	$\frac{3}{4}$	$\frac{1}{8}$	

A TRIP TO THE FAERÖE GROUNDS.

In April a trip to Faeröe was made by Mr. W. Chalmers, on board the steam trawler "Star of the Wave," and records were taken by him and the skipper, Mr. S. Caie, which are here included. The vessel left Aberdeen on the morning of the 22nd and arrived at Faeröe early in the morning of the 24th, the voyage occupying forty and a half hours. Nearly all the fishing took place to the south-east of Fuglö, in deep water, and the weather was stormy, the vessel being compelled to lay to for twelve hours. The first haul was made about six and a half miles off, Fuglö bearing N.W.; the trawl was dropped in 55 fathoms and hauled after four hours in 73 fathoms. The catch comprised 1048 fishes, of which all but three were marketable. Here it may be said that the offal or unmarketable fishes in the drags at the Faeröe deep water grounds bear a very small proportion to the marketable fishes, and offer a contrast to what usually obtains in, say, the Moray Firth. In this haul the number of codlings was very large, viz., 520, all of them marketable; there were 5 cod, a ling, a tusk, 16 halibuts, 400 haddocks, mostly large and all marketable, 30 lemon dabs and 9 plaice, as well as 21 cat-fish, and a few others. In the next haul, on the same ground, the net was split, and a complete record was not made of the catch. It included, however, a basket of codling, 1 cod, 906 haddocks (all but 1 marketable), 4 halibuts, a ling, 11 cat-fish, 18 plaice, and 28 lemon dabs; there were 15 offal fish. The next drag, also on the same grounds, in from 53 to 57 fathoms, for four hours, yielded 898 fish, all but 24 marketable. They consisted of the same kinds, codling being less numerous, and the haddocks numbered 778, all of them being marketable.

A number of hauls were made on this ground on the 24th and 25th, in some of which the net was split, and in one the cod-end (of single twine on this occasion for experimental purposes) gave way and most of the catch was lost. In one of the drags, for four hours, 15 baskets of large haddocks, one of mediums, and one and a half of smalls were taken, with about 200 cod, and a number of halibut, plaice, and ling. On the afternoon of the 25th the weather was so bad that the vessel had to run for shelter, and the next forenoon fishing was resumed about 15 miles off Viderö in 60 to 67 fathoms, but with poor results, the net being split and a gale blowing. In the evening, fishing off Fuglö was resumed, and a number of hauls were taken in from 48 to 75 fathoms, haddocks, codlings, and cod forming the bulk of the catches.

Altogether the vessel made 29 hauls in the Faeröese waters, leaving for Aberdeen on the morning of the 30th, and arriving in the port early on the morning of May 2. In some of the hauls the net was torn, and in other cases the catch was not completely enumerated. In 17 recorded hauls, the aggregate time of fishing being sixty-seven hours and twenty minutes, 13,932 fishes were captured, of which 13,767 were marketable and 164 unmarketable. The ratio per ten hours of fishing was 2069·2 fishes, the marketable being 2044·8 and the unmarketable 24·4 per ten hours. The total number of the principal species taken in these hauls, and the ratio per ten hours' fishing, are given in the following Table:—

[TABLE.]

	Cod.	Cod-ling.	Ling.	Coal-fish.	Haddock.	Whiting.	Cat-fish.	Tusk.
No. .	538	3,275	12	77	8,846	5	175	3
Average	79·7	486·4	1·8	11·4	1312·9	0·74	26·0	0·44

	Halibut.	Plaice.	Lemon Dab.	Common Dab.	Turbot.	Megrim.	Angler.
No. .	165	191	331	180	4	1	61
Average	24·5	28·4	49·0	27·0	0·6	0·15	9·0

The number of cod in any of the drags varied greatly—from *nil* to 160 ; the number of codling ranged from 50 to 520 and 484, and in these hauls they were all marketable. The total of haddocks in the different hauls varied from 242 to 1153, and they were all marketable. Cat-fish were got in each of the 17 drags, their numbers varying from 4 to 21 ; halibut were taken in 16 of the hauls, the numbers ranging from *nil* to 34 in the different hauls. Plaice were also got in each haul, the numbers varying from 4 to 27. Among lemon dabs, also taken in each of the drags, the numbers varied from 2 to 46.

At already stated, the proportion of the unmarketable fishes from these grounds is small, and the sizes of the marketable are also large. The sizes of the haddocks and plaice taken were as follows :—

	1st	2nd	3rd	4th	Unmarketable	Total.
Haddock,	5,999	535	1,944	—	—	8,478
Plaice,	175	16	—	—	—	191

The haddocks in one of the hauls referred to, 362 in number, were not classified ; and among the “ 1st ” in the above list are a number of “ extra large.”

One haul was made for thirty minutes with a small-meshed net around the cod-end, in from 58 to 63 fathoms, south-east of Fuglo. The catch in the cod-end numbered 114 fishes, all marketable, comprising 1 cod, 48 codling, 49 haddocks, 2 cat-fish, 1 halibut, 2 plaice, 3 lemon dabs, 7 common dabs, and 1 thornback. Only 9 fishes were in the small-meshed net, viz. 3 haddocks, 253, 257, and 271mm. ; 1 common dab, of 159mm., and 5 sand-eels.

Among the halibut were some small ones which were brought back and measured ; they ranged from 220mm. to 312mm. (eight and three-quarter inches to twelve and a quarter inches), and were 7 in number.

The cod were stated to be spawning, and the haddocks far advanced. The quantity of the roes of haddocks and cod obtained and brought to market was ten and a half boxes.

According to the market statistics, the total quantity of fish landed from this voyage amounted to 391½ cwts., as follows :—

Cod.	Codling.	Ling.	Tusk.	Saithe.	Haddock.	Halibut.	Lemon Dab.	Plaice.
111¼	84	6	½	16	112	10½	6	14
			Dabs.	Skate.	Cat-fish.	Monk.		
			¾	2	26	2		

TRAWLING INVESTIGATIONS—TABLE I.

Place	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
1. Aber- deen Bay, off New- burgh.	1904. Jan. 14.	..	..	..	5 to 20	7.0 a.m.	11.5 a.m.	Cod, Codling, Haddock (1), .. " (2), .. " (3), .. Whiting, Plaice (3), .. Starry Ray, ..	2 57 123 79 54 .. 45 ..	.. 9 8 5 .. 5	2 66 264 5 45 5	
									360	27	387	
2. "	"	41.7	45.3	48.0	4½ to 9	11.30 a.m.	3.30 p.m.	Cod, Codling, Haddock (1), .. Whiting, Plaice (3), .. Com. Dab, .. Long Rough Dab, Herring, Sprat,	1 79 20 .. 20 28 .. .. ..	.. .. 11 18 .. 1 4 14 22	1 79 31 18 20 29 4 14 22	Wind S.W.; strong breeze; rain.
									148	70	218	
3. "	"	..	..	..	8 to 9	3.55 p.m.	8.0 p.m.	Cod, Codling, Haddock (1), .. " (2), .. Whiting, Plaice (3), .. " (4), .. Starry Ray, ..	2 50 187 30 217 .. 2 4 6 ..	.. 3 4 11	2 53 .. 217 4 .. 6 11	
									275	18	293	
4. Off Lybster.	Jan. 17.	..	..	..	25	3.30 a.m.	7.30 a.m.	Cod, Codling, Haddock (3), .. Whiting, Plaice (1), .. " (2), .. " (3), .. " (4), .. Com. Dab, ..	20 12 46 .. 4 18 83 28 128 ..	.. 3 100 15 28	20 15 146 15 128 28	S.W. strong breeze.
									206	146	352	
5. "	"	42.4	46.9	47.0	34 to 36	10.0 a.m.	2.10 p.m.	Cod, Codling, Haddock (1), .. " (2), .. " (4), .. Whiting, Cat-fish, Plaice (1), .. " (2), .. " (3), .. Com. Dab, .. Starry Ray, ..	3 4 12 10 135 157 .. 1 36 76 50 162 .. 3	.. .. .. .. .. 158 24 10 ..	3 4 315 24 1 162 10	S.W. light breeze; sea smooth.
									330	192	522	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
6. Off Lybster.	1904. Jan. 17.	..	..	..	34 to 35	2.50 p.m.	7.0 p.m.	Cod, Codling, Haddock (1), .. " (2), " (4), —100 Whiting, Coal-fish, Plaice (1), " (2), " (3), —195 Witch, Com. Dab, Skate,	1 7 4 2 94 100 .. 38 109 48 195 2 .. 5	.. 7 16 22 ..	1 14 204 16 1 195 2 22 5	
									311	149	460	
7. "	"	..	..	..	"	7.30 p.m.	11.30 p.m.	Cod, Codling, Coal-fish, Haddock (1), .. " (2), " (4), —191 Whiting, Plaice (1), " (2), " (3), —107 Com. Dab, Skate, Angler,	1 6 2 9 14 168 191 .. 14 61 32 107 .. 3 3	.. 6 160 4 48 f ..	1 12 2 291 14 107 48 10 3	
									313	175	488	
8. "	Jan. 18.	..	..	..	"	5.0 a.m.	9.20 a.m.	Cod, Codling, Haddock (1), .. " (2), " (4), —162 Whiting, Plaice (1), " (2), " (3), —128 Com. Dab, Skate,	2 6 8 14 140 162 .. 10 45 73 128 .. .. ..	.. 3 92 25 28 2	2 9 254 25 128 28 2	
									298	150	448	
9. "	"	41.4	46.6	47.0	32 to 34	11.0 a.m.	12 noon.	Cod, Codling, Haddock (1), .. " (2), —103 Plaice (2), —108	1 5 60 43 103 1 108	.. .. .. .. .. .. ..	1 3 103 1 108	Net all split. Left for Sandside Bay, but forced to return; too much wind in Pentland Firth.

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Alt.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
10. Off Lybster.	1904. Jan. 18.	..	..	..	25 to 26	4.30 p.m.	8.30 p.m.	Codling,	12	17	29	
								Haddock (1), ..	10	..	..
								" (2), ..	2	..	..
								" (4), ..	72	..	..
								— 84	..	190	274	
								Whiting, .. ..	..	38	38	
								Brill,	1	..	1	
								Lemon Dab, ..	33	..	33	
								Plaice (1), ..	7	..	..
								" (2), ..	31	..	..
								— 38	..	..	38	
								Com. Dab, ..	..	72	72	
								Long Rough Dab,	..	7	7	
									168	324	492	
11. "	Jan. 18 and 9.	..	..	..	"	9.35 p.m.	1.35 a.m.	Cod,	2	..	2	
								Codling,	14	11	25	
								Haddock (1), ..	6	..	..
								" (2), ..	8	..	..
								" (4), ..	143	..	..
								— 157	..	96	253	
								Whiting, .. ..	..	30	30	
								Plaice (1), ..	6	..	..
								" (2), ..	38	..	..
								" (3), ..	40	..	..
								— 84	..	..	84	
								Com. Dab, ..	..	46	46	
								Skate,	4	..	4	
								Angler, .. ..	..	8	8	
									261	191	452	
12. "	Jan. 19.	44'4	46'7	46'0	23 to 24	3.30 a.m.	8.0 a.m.	Codling,	6	11	17	S.W. light breeze ; sea smooth.
								Haddock (1), ..	14	..	..
								" (2), ..	30	..	..
								" (4), ..	28	..	..
								— 72	..	89	161	
								Whiting, .. ..	..	42	42	
								Brill,	1	..	1	
								Lemon Dab, ..	6	..	6	
								Plaice (1), ..	3	..	..
								" (2), ..	14	..	..
								" (3), ..	16	..	..
								— 33	..	..	33	
								Herring, .. ..	..	1	1	
								Skate, .. ..	..	2	2	
								Angler, .. ..	..	1	1	
									118	146	264	
13. Sandside Bay	Jan. 20.	..	..	..	40 to 43	1.30 a.m.	5.35 a.m.	Cod,	1	..	1	
								Codling,	4	6	10	
								Haddock (1), ..	2	..	..
								" (2), ..	28	..	..
								" (4), ..	41	..	..
								— 71	..	68	139	
								Whiting, .. ..	..	20	20	
								Grey Gurnard, ..	..	14	14	
								Lemon Dab, ..	30	..	30	
								Plaice (1), ..	9	..	..
								" (2), ..	20	..	..
								" (3), ..	16	..	..
								— 45	..	..	45	
								Com. Dab, ..	18	..	18	
								Skate, .. ..	..	16	16	
								Dog-fish, ..	..	31	31	
									169	155	324	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over-board.	Total No.	
18. Off Ord of Caithness.	1904. Jan. 21 and 22.	23 to 24	9.0 p.m.	1.10 a.m.	Cod,	Wind N.W., strong breeze; very dull.
								Codling,	8	..	8	
								Haddock (1), ..	4	..	..
								" (2), ..	36	..	..
								" (3), ..	18	..	..
								— 58	..	41	99	
								Whiting, .. ..	..	5	5
								Plaice (1), ..	17	..	..
								" (2), ..	30	..	..
								" (3), ..	22	..	..
								— 69	..	..	69
								Com. Dab, ..	..	32	32
								Long Rough Dab, ..	..	14	14
								Skate,	3	..	3	
								Angler .. ..	..	12	12
								— 138	..	104	242	
19. "	Jan. 22.	..	..	..	24	7.0 a.m.	11.5 a.m.	Codling,	10	..	10
								Coal-fish, ..	2	..	2	
								Haddock (1), ..	15	..	..
								" (2), ..	22	..	..
								" (3), ..	13	..	..
								— 50	..	87	137	
								Whiting, .. ..	..	8	8
								Cat-fish, ..	1	..	1	
								Plaice (1), ..	8	..	..
								" (2), ..	20	..	..
								" (3), ..	37	..	..
								" (4), ..	5	..	..
								— 70	..	..	70
								Com. Dab, ..	..	36	36
								Long Rough Dab, ..	..	14	14
								Skate,	5	..	5	
								— 138	..	145	283	
20. "	"	41.0	48.7	45½.0	24 to 25	11.45 a.m.	4.10 p.m.	Codling,	8	8	
								Coal-fish, ..	2	..	2	
								Haddock (1), ..	..	..	..
								" (2), ..	..	..	..
								" (3), ..	..	..	..
								— ..	..	102	102
								Whiting, .. ..	..	16	16
								Cat-fish, ..	1	..	1	
								Conger-Eel, ..	2	..	2	
								Plaice (1), ..	11	..	..
								" (2), ..	26	..	..
								" (3), ..	29	..	..
								" (4), ..	6	..	..
								— 72	..	..	72
								Com. Dab, ..	..	50	50
								Long Rough Dab, ..	..	21	21
								Skate,	2	3	5	
								— 79	..	200	279	
21. "	"	23 to 25	4.35 p.m.	8.45 p.m.	Cod,	4	..	4	
								Codling, ..	7	5	12	
								Haddock (1), ..	16	..	..
								" (2), ..	20	..	..
								— 36	..	92	128	
								Whiting, ..	..	21	21
								Plaice (1), ..	14	..	..
								" (2), ..	22	..	..
								" (3), ..	10	..	..
								— 46	..	..	46
								Com. Dab, ..	..	30	30
								Long Rough Dab, ..	..	25	25
								Skate,	2	2	4	
								— 95	..	175	270	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
22. Witch Ground, off Kin- naird Head.	1904. Jan. 23.	..	..	..	40 to 45	4.30 a.m.	8.45 a.m.	Cod, Codling, Haddock (1), .. " (2), .. " (4), .. Whiting, Witch, Com. Dab, Long Rough Dab,	11 1 20 26 32 — 78 78 .. ..	.. .. .. .. .. (653) (294) .. (2,142) (1,281)	.. .. .. .. .. .. .. .. ..	"Offal" consisted of seven baskets, one of which was counted.
									168	(4,375)	..	

Part III.—Twenty-third Annual Report

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over-board.	Total No.	
1. Burghhead Bay.	1904. Mar. 28.	..	..	..	9 to 30	4.30 p.m.	8.30 p.m.	Cod,	2	..	2	
								Codling, .. ..	..	8	8	
								Coal-fish	2	..	2	
								Haddock (3), ..	200	20	220	
								Whiting,	130	20	150	
								Cat-fish,	5	..	5	
								Brill,	24	..	24	
								Plaice (1), ..	8	..	..
								" (2),	8	..	..
								" (3),	206	..	..
								—222 .. ..	..	..	222	
								Lemon Dab (1), ..	19	..	19	
								Witch (1),	112	19	131	
								Com. Dab,	53	313	366	
								Long Rough Dab, ..	..	14	14	
								Thornback Ray, ..	11	6	17	
								Angler, .. ..	..	17	17	
								Herring, .. ..	..	5	5	
									780	422	1202	
2. "	Mar. 28 and 29.	..	..	..	6 to 16	8.55 p.m.	12.55 a.m.	Cod,	1	..	1	
								Codling, .. ..	..	10	10	
								Haddock (3), ..	37	52	89	
								Whiting,	23	16	39	
								Cat-fish,	6	..	6	
								Brill,	40	..	40	
								Plaice (1), ..	28	..	..
								" (2),	104	..	..
								" (3),	70	..	..
								" (4),	100	..	..
								—302 .. ..	..	23	325	
								Lemon Dab,	20	..	20	
								Witch,	15	20	35	
								Com. Dab,	90	270	360	
								Thornback Ray, ..	33	8	41	
								Angler,	7	2	9	
									574	401	975	
3. "	Mar. 29.	..	..	..	4 to 10	1.15 a.m.	5.35 a.m.	Cod,	3	..	3	
								Codling,	3	..	3	
								Haddock (1), ..	1	..	..
								" (3),	17	..	..
								—18 .. ..	..	4	22	
								Whiting,	7	2	9	
								Cat-fish,	2	..	2	
								Grey Gurnard, ..	..	1	1	
								Turbot,	2	..	2	
								Brill,	23	..	23	
								Plaice (1), ..	45	..	..
								" (2),	80	..	..
								" (3),	120	..	..
								—245 .. ..	..	72	317	
								Lemon Dab,	10	2	12	
								Witch,	9	5	14	
								Com. Dab,	80	191	271	
								Long Rough Dab, ..	..	4	4	
								Thornback,	11	1	12	
								Angler, .. ..	..	1	1	
								Lumpsucker, ..	..	2	2	
									413	285	698	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
4. Burghead Bay.	1904. Mar. 29.	..	..	..	4 to 16	5.50 a.m.	11.16 a.m.	Cod, Codling, Haddock (1), " (3), —165 Whiting, Cat-fish, Grey Gurnard, Turbot, Brill, Plaice (1), " (2), " (3), " (4), —576 Lemon Dab, Witch, Flounder, Com. Dab, Long Rough Dab, Angler, Herring, Thornback, Lumpsucker, 1181 1150 2331	2 16 15 150 43 60 4 11 2 13 23 92 226 235 576 30 5 .. 260 180 23 .. 14 ..	.. 9 15 .. 7 16 9 856 180 5 8 1 1	2 25 .. 208 208 75 4 18 2 13 576 30 21 9 1116 180 28 8 15 1	
5. Off Lossiemouth, Lossiemouth bearing W.	"	..	..	..	13	1.35 p.m.	5.35 p.m.	Cod, Codling, Haddock (1), " (2), " (3), —36 Whiting, Cat-fish, Grey Gurnard, Brill, Plaice (1), " (2), " (3), " (4), —107 Lemon Dab, Long Rough Dab, Com. Dab, Lumpsucker, 191 79 270	1 2 6 0 30 36 24 1 10 8 9 43 39 16 107 2 .. .. ..	.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. 10 68 1	1 2 36 24 1 10 8 107 2 68 1	Trawling round "Dan."
6. Off Burghead.	Mar. 30.	..	..	..	44 to 45	12.40 a.m.	5.0 a.m.	Cod, Codling, Hake, Haddock (1), " (2), " (3), —788 Whiting, Grey Gurnard, Brill, Plaice (1), " (2), " (3), —20 Witch, Lemon Dab, Megrim, Com. Dab, Angler, Long Rough Dab, Thornback, 1280 358 1638	8 4 5 67 28 693 788 146 3 1 5 13 2 20 180 105 1 14 5 .. ..	.. 2 29 6 1 89 1 .. 69 2 150 9	8 6 5 817 152 4 1 20 269 106 1 83 7 150 9	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
7. Off Burghhead. Covesen, S.W. by W.	1904, Mar. 30.	44 to 45	5.20 a.m.	8.55 a.m.	Cod,	7	..	7	
								Codling,	3	..	3	
								Haddock (1), ..	138	..	..
								" (2), ..	102	..	..
								" (3), ..	1658	..	..
								—1898	..	29	1927	
								Whiting,	246	5	251	
								Hake,	17	..	17	
								Grey Gurnard, ..	1	..	1	
								Brill,	1	..	1	
								Plaice (1), ..	3	..	..
								" (2), ..	6	..	..
								" (3), ..	1	..	..
								—10	..	..	10
								Lemon Dab, ..	26	1	27	
								Witch,	245	37	282	
								Megrim,	1	..	1	
								Com. Dab, ..	25	98	123	
								Long Rough Dab, ..	..	1358	1358
								Herring, .. ..	..	1	1
								Norway Pout, ..	..	10	10
								Angler,	3	2	5	
								Grey Skate, ..	..	2	2
								Thornback, ..	..	1	1
								Bib, .. ..	..	1	1
								Lumpenus, ..	..	2	2
								—2483	..	1547	4030	
S. "	"	16 to 44	9.15 a.m.	11.40 a.m.	Cod,	4	..	4	
								Codling,	3	3	6	
								Ling,	2	..	2	
								Haddock (1), ..	30	..	..
								" (2), ..	24	..	..
								" (3), ..	762	..	..
								—816	..	21	837	
								Whiting,	133	1	139	
								Grey Gurnard, ..	13	7	20	
								Brill,	3	..	3	
								Plaice (1), ..	9	..	..
								" (2), ..	25	..	..
								" (3), ..	11	..	..
								—45	..	..	45
								Lemon Dab, ..	45	6	51	
								Witch,	4	2	6	
								Com. Dab, ..	8	90	98	
								Long Rough Dab, ..	..	212	212
								Angler,	2	1	3	
								Norway Pout, ..	..	1	1
								—1083	..	344	1427	
9. Dornoch Firth.	"	5 to 11	3.30 p.m.	7.30 p.m.	Cod,	69	..	69	Weather fine; sea smooth.
								Codling,	1	..	1	
								Coal-fish, ..	2	..	2	
								Haddock, ..	7	..	7	
								Cat-fish, ..	1	..	1	
								Plaice,	133	5	138	
								Lemon Dab, ..	7	..	7	
								Witch,	30	6	1	
								Com. Dab, ..	95	28	123	
								Flounder, ..	8	4	12	
								Thornback Ray, ..	..	3	3
								Grey Skate, ..	..	..	..
								—354	..	46	400	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over-board.	Total No.	
10. Dornoch Firth.	1904. Mar. 30.	..	..	..	5 to 16	3.0 p.m.	12.0 p.m.	Cod,	43	..	43	
								Cat-fish,	2	..	2	
								Plaice (1),	16	..	..
								" (2),	14	..	..
								" (3),	57	..	..
								— 37	..	..	87	
								Lemon Dab,	1	..	1	
								Com. Dab,	6	2	8	
								Flounder,	36	2	38	
								Thornback Ray,	19	..	19	
								Grey Skate,	5	5	10	
								Sprat, .. ..	..	2	2	
								— 199	..	11	210	
11. "	Mar. 31.	..	..	..	10 to 15	1.0 a.m.	5.0 a.m.	Cod,	282	..	282	
								Coal-fish,	5	..	5	
								Haddock,	3	..	3	
								Plaice (1),	13	..	..
								" (2),	8	..	..
								— 21	..	..	21	
								Lemon Dab,	9	..	9	
								Witch,	7	..	7	
								Thornback,	6	..	6	
								— 333	..	..	333	
12. "	"	..	..	..	10 to 16	5.55 a.m.	10.0 a.m.	Cod,	259	..	259	
								Codling,	1	1	2	
								Haddock,	1	..	1	
								Cat-fish,	2	..	2	
								Brill,	2	..	2	
								Plaice (1),	31	..	..
								" (2),	14	..	..
								— 45	..	..	45	
								Lemon Dab,	7	..	7	
								Witch,	6	..	6	
								Flounder,	4	2	6	
								Com. Dab,	1	4	5	
								Thornback Ray,	24	7	31	
								— 352	..	14	366	
13. "	"	44.1	41.5	41.4	5 to 10	10.50 a.m.	2.50 p.m.	Cod,	43	..	43	
								Coal-fish,	2	..	2	
								Cat-fish,	2	..	2	
								Brill,	2	..	2	
								Plaice (1),	15	..	..
								" (2),	31	..	..
								" (3),	73	..	..
								" (4),	147	..	..
								— 266	..	1	267	
								Flounder,	82	..	82	
								Lemon Dab,	1	..	1	
								Com. Dab,	20	5	25	
								Thornback,	20	..	20	
								Grey Skate, .. ..	..	6	6	
								— 438	..	12	450	
14. "	"	..	..	..	7 to 15	5.25 p.m.	9.25 p.m.	Cod,	58	..	58	
								Codling,	3	..	3	
								Haddock (1),	24	..	24	
								Cat-fish,	5	..	5	
								Plaice (1),	11	..	..
								" (2),	13	..	..
								" (4),	5	..	..
								— 29	..	..	29	
								Lemon Dab,	8	..	8	
								Witch,	1	..	1	
								Flounder,	18	..	18	
								Long Rough Dab, .. ..	..	3	3	
								Thornback,	15	..	15	
								Grey Skate, .. ..	..	9	9	
								— 161	..	12	173	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over-board.	Total No.	
1. From off Findhorn to off Burghead.	1904. April 1.	..	41°3	41°8	30 to 32	9.0 a.m.	10.0 a.m.	Cod,	7	..	7	
								Coal-fish,	1	..	1	
								Haddock (1),	5	..	..
								" (2),	5	..	..
								" (3),	6	..	..
								Whiting,	16	1	17	
								Witch,	17	3	20	
								Megrim,	165	10	175	
								Lemon Dab,	1	..	1	
								Com. Dab,	9	..	9	
								Long Rough Dab,	10	2	12	
								Flounder,	1	13	14	
								Thornback,	1	3	4	
								Angler,	1	..	1	
								Herring, .. ..	..	13	13	
								Norway Pout, .. ..	..	27	27	
								Lumpenuts, .. ..	..	40	40	
								Sprat, .. ..	..	12	12	
									..	3	3	
									229	127	356	
2. Smith Bank.	"	..	..	..	22	3.20 p.m.	4.5 p.m.	Codling,	10	2	12	Net caught on bottom and was hauled. Small-meshed net experiment.
								Haddock (1, 2),	26	..	..
								" (3),	15	..	..
								Whiting,	41	1	42	
								Cat-fish,	3	1	4	
								Plaice,	3	..	3	
								Lemon Dab,	2	..	2	
									6	..	6	
									65	4	69	
3. Deep Hole, off Fraserburgh.	Sept. 23.	..	54½	53¼	75	11.45	1.45	Cod,	44	..	44	
								Codling,	150	20	170	
								Ling, .. ..	..	1	1	
								Haddock (1),	110	..	..
								" (2),	99	..	..
								" (3),	421	..	..
								Whiting,	630	195	825	
								Grey Gurnard,	44	..	44	
								Cat-fish, .. ..	..	11	11	
								Lemon Dab,	1	..	1	
								Witch,	18	..	18	
								Megrim,	1	..	1	
								Long Rough Dab,	11	..	11	
								Grey Skate, .. ..	..	44	44	
									1	6	7	
									900	277	1177	
4. Burghead Bay.	Sept. 29.	..	..	..	5 to 8	1.20 a.m.	5.30 a.m.	Codling,	1	..	1	
								Haddock (1),	7	..	..
								" (2),	3	..	..
								" (3),	61	..	..
								Grey Gurnard,	71	300	371	
								Sapphirine Gurnard, .. ..	..	5	5	
								Lemon Dab, .. ..	..	1	1	
								Plaice (3),	2	..	2	
								Com. Dab,	108	8	116	
								Long Rough Dab, .. ..	..	92	92	
								Thornback, .. ..	..	6	6	
								Angler,	2	..	2	
									..	1	1	
									184	413	597	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
5. Burghead Bay.	1904. Sept. 29.	..	..	..	6 to 11½	6.5 a.m.	10.15 p.m.	Codling, ..	3	..	3	
								Haddock (1), ..	20	..	..
								" (2), ..	45	..	..
								" (3), ..	430	..	..
								— 405	699	..	1194	
								Grey Gurnard, ..	32	..	32	
								Whiting, ..	27	16	43	
								Plaice (3), ..	27	..	27	
								Lemon Dab, ..	3	..	3	
								Com. Dab, ..	..	35	35	
								Thornback, ..	1	..	1	
								Angler, ..	..	1	1	
									556	783	1339	
6. Between Lossie-mouth and Burghead.	"	..	54.0	54.0	7 to 12	11.15 a.m.	2.30 p.m.	Cod, ..	42	..	42	
								Codling, ..	15	..	15	
								Haddock (1), ..	25	..	..
								" (2), ..	14	..	..
								" (3), ..	138	..	..
								— 177	170	..	347	
								Whiting, ..	33	6	39	
								Grey Gurnard, ..	..	22	22	
								Plaice, ..	11	..	11	
								Lemon Dab, ..	7	..	7	
								Witch, ..	2	..	2	
								Angler, ..	..	4	4	
								Com. Dab, ..	..	9	9	
									287	211	498	
7. "	"	..	..	..	9 to 10	4.55 p.m.	9.30 p.m.	Cod, ..	7	..	7	
								Codling, ..	14	..	14	
								Haddock (1), ..	22	..	..
								" (2), ..	15	..	..
								" (3), ..	250	..	..
								— 287	300	..	587	
								Whiting, ..	..	18	18	
								Grey Gurnard, ..	..	23	23	
								Plaice, ..	145	..	145	
								Lemon Dab, ..	5	..	5	
								Com. Dab, ..	..	55	55	
								Angler, ..	..	33	33	
									458	434	892	
8. Between Hopeman and Cove-sea Light.	Sept. 29 and 30.	..	..	..	8 to 10	10.0 p.m.	2.0 a.m.	Cod, ..	2	..	2	
								Codling, ..	9	..	9	
								Whiting, ..	..	15	15	
								Haddock (1), ..	19	..	..
								" (2), ..	33	..	..
								" (3), ..	175	..	..
								— 227	..	..	227	
								Grey Gurnard, ..	..	19	19	
								Brill, ..	3	..	3	
								Plaice, ..	423	..	423	
								Lemon Dab, ..	4	..	4	
								Black Sole, ..	4	..	4	
								Com. Dab, ..	..	89	89	
								Angler, ..	..	42	42	
								Thornback, ..	4	..	4	
								Wrasse, ..	1	..	1	
									677	165	842	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
9. Off Hopeman.	1904. Sept. 30.	..	53.5	54.0	7 to 9	6.55 a.m.	11.15 a.m.	Codling, ..	6	1	7	
								Haddock (1), ..	3	..	..
								" (2), ..	5	..	..
								" (3), ..	16	..	..
								Grey Gurnard, ..	24	34	58	
								Brill, ..	1	..	1	
								Plaice (1), ..	53	..	..
								" (2), ..	77	..	..
								Lemon Dab, ..	130	..	130	
								Com. Dab, ..	11	..	11	
								Thornback, ..	9	144	153	
									1	..	1	
									182	302	484	
10. Off Lossie- mouth.	"	..	..	..	17	1.0 p.m.	2.45 p.m.	Codling, ..	2	..	2	
								Haddock (1), ..	97	..	..
								" (2), ..	67	..	..
								" (3), ..	150	..	..
								Whiting, ..	314	..	314	
								Grey Gurnard, ..	9	200	200	
								Plaice (1), ..	30	..	..
								" (2), ..	50	..	..
									80	..	80	
									405	200	605	
11. Between Lossiemouth and Burghead.	"	..	..	..	7 to 9	3.25 p.m.	7.30 p.m.	Cod, ..	3	..	3	
								Codling, ..	6	..	6	
								Haddock (2), ..	48	25	73	
								Grey Gurnard, ..	1	132	132	
								Turbot, ..	..	..	1	
								Brill, ..	3	..	3	
								Plaice (1), ..	14	..	..
								" (2), ..	31	..	..
								Lemon Dab, ..	45	..	45	
								Com. Dab, ..	1	..	1	
								Angler, ..	3	41	44	
								Thornback, ..	..	2	2	
									..	1	1	
									110	201	311	
12. "	Sept. 30 & Oct. 1	..	..	..	7 to 10	9.35 p.m.	1.30 a.m.	Cod, ..	4	..	4	A few crabs.
								Codling, ..	32	19	51	
								Lythe, ..	5	..	5	
								Haddock (1), ..	23	..	..
								" (2), ..	80	..	..
								" (3), ..	443	..	..
								Whiting, ..	546	879	1425	
								Grey Gurnard, ..	..	7	7	
								Turbot, ..	2	..	2	
								Brill, ..	8	..	8	
								Lemon Dab, ..	7	..	7	
								Plaice (1), ..	143	..	..
								" (2), ..	209	..	..
								Com. Dab, ..	352	6	358	
								Angler, ..	14	1068	1082	
								Thornback, ..	..	3	3	
									2	2	4	
									972	2185	3157	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No thrown Over- board.	Total No.	
13. Between Lossiemouth and Burghead.	1904 Oct. 1.	7 to 10	2.55 a.m.	6.45 a.m.	Cod,	3	..	3	
								Codling,	8	1	9	
								Coal-fish, .. ..	..	4	4
								Haddock (1),	4	..	..
								" (2),	9	..	..
								" (3),	75	..	..
								Grey Gurnard,	88	66	154	
								Turbot, .. ..	..	64	64
								Brill,	1	..	1	
								Plaice (1),	2	..	2	
								" (2),	47	..	..
								" (3),	43	..	..
								Lemon Dab,	90	1	91	
								Com. Dab,	2	..	2	
								Angler, .. ..	..	121	121
14. Dornoch Firth.	"	..	53.9	54.0	10 to 12	9.35 a.m.	10.40 a.m.	Codling,	3	..	3	
								Haddock (1),	93	..	..
								" (2),	83	..	..
								" (3),	506	..	..
								Grey Gurnard,	682	60	742	
								Plaice, .. ..	..	22	22
								Com. Dab,	12	..	12	
									..	30	30	
									697	112	809	
15. "	"	6 to 10	noon, 4 p.m.		Cod,	3	..	3	
								Codling,	6	..	6	
								Haddock,	6	..	6	
								Grey Gurnard, .. ..	..	20	20
								Plaice (1),	15	..	..
								" (2),	25	..	..
								Com. Dab,	40	45	85	
								Thornback, .. ..	..	12	12
									1	..	1	
									56	77	133	
16. Off Lybster.	Oct. 3.	..	53.9	53.9	26 to 34	8.20 a.m.	12 30 p.m.	Codling,	2	21	23	A quantity of squid.
								Haddock (1),	3	..	..
								" (2),	32	..	..
								" (3),	305	..	..
									340	471	811	
								Whiting,	4	..	4	
								Grey Gurnard, .. ..	..	60	60
								Plaice	8	1	9	
								Lemon Dab,	44	14	58	
								Com. Dab, .. ..	..	14	14
								Long Rough Dab, .. ..	..	3	3
								Thornback,	2	2	4	
								Dog-fish, .. ..	..	2	2
								Angler, .. ..	..	3	3
									400	591	991	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over-board.	Total No.	
17. Smith Bank, about middle.	1904 Oct. 3.	53·8	19 to 20	2·0 p.m.	3·10 p.m.	Codling,	1	..	1	Small-meshed net experiment. Towed S.S.W. and back. Fifteen baskets of gurnards; one counted contained 178, large and small.
								Whiting,	1	..	1	
								Haddock (1), ..	8	..	..
								" (2),	4	..	..
								" (3),	67	..	..
								— 79	..	..	79
								Plaice (1),	2	..	..
								" (2),	11	..	..
								— 13	..	..	13
								Grey Gurnard, ..	..	..	(2670)
								Com. Dab, .. ..	..	76	76
								
18. Aberdeen Bay, N. of Newburgh.	Oct. 4.	6 to 13	12·20 a.m.	4·30 a.m.	Haddock (1), ..	4	
								" (2),	2	
								" (3),	33	
								— 39	103	..	142	
								Whiting,	48	21	69	
								Grey Gurnard,	13	13	
								Plaice (3),	99	..	99	
								Lemon Dab,	1	..	1	
								Com. Dab,	55	..	55	
								Long Rough Dab,	3	3	
								Angler,	2	2	
								— 242	142	..	384	
19. Aberdeen Bay.	"	..	53·0	53·2	5 to 13	5·15 a.m.	9·20 a.m.	Haddock,	2	..	2	
								Turbot,	5	..	5	
								Plaice (1),	36	
								" (2),	98	
								" (3),	131	
								— 265	265	
								Lemon Dab,	2	..	2	
								Com. Dab,	298	298	
								— 274	298	..	572	
20. Aberdeen Bay. Shot off Black Dog and trawled as far as Newburgh.	Nov. 8.	49½	49·0	50·0	11 to 13	11·45 a.m.	3·0 p.m.	Cod,	9	..	9	N.W. good breeze; sea choppy.
								Codling,	56	7	63	
								Haddock (1), ..	43	..	..
								" (2),	25	..	..
								" (3),	102	..	..
								— 170	15	..	185	
								Whiting,	51	103	154	
								Grey Gurnard, ..	..	1	1
								Halibut,	1	..	1	
								Turbot,	3	..	3	
								Plaice (2),	31	..	..
								" (3),	42	..	..
								— 73	..	..	73
								Com. Dab,	59	104	163	
								Long Rough Dab, ..	..	27	27
								Skate, .. ..	..	5	5
								Angler, .. ..	..	5	5
								— 422	267	..	689	
21. Aberdeen Bay. Off Newburgh.	"	7 to 12	3·30 p.m.	6·35 p.m.	Cod,	12	..	12	N.W. strong breeze.
								Codling,	13	..	13	
								Haddock (1), ..	51	..	..
								" (2),	20	..	..
								— 71	10	..	81	
								Whiting, .. ..	..	26	26
								Ling,	1	..	1	
								Grey Gurnard, ..	..	8	8
								Plaice (2),	8	..	..
								" (3),	7	..	..
								— 15	..	..	15
								Com. Dab, .. ..	..	33	33
								Long Rough Dab, ..	..	12	12
								Skate, .. ..	..	46	46
								Angler, .. ..	..	2	2
								— 112	137	..	249	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Alt.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over-board.	Total No.	
22. Aberdeen Bay.	1904. Nov. 8.	12 to 13	7.10 p.m.	10.15 p.m.	Cod,	13	..	13	Wind S. ; moderate breeze.
								Codling,	9	..	9	
								Coal-fish,	1	..	1	
								Haddock (1),	8	..	..
								" (2),	14	..	..
								— 22	..	3	25	
								Whiting, .. .. .	..	26	26
								Plaice (2),	10	..	..
								" (3),	16	..	..
								— 26	..	..	26
								Com. Dab, .. .. .	..	31	31
								Long Rough Dab, .. .. .	..	10	10
								Skate, .. .. .	..	79	79
								Angler, .. .. .	..	2	2
									71	151	222	
23. Aberdeen Bay. Off Collieston.	Nov. 8 and 9.	10.45 p.m.	2.30 a.m.	Cod,	4	..	4	Wind S., increasing in force.
								Codling,	18	..	18	
								Haddock,	17	14	31	
								Whiting,	18	53	71	
								Plaice (2),	15	..	..
								" (3),	12	..	..
								— 27	..	..	27
								Com. Dab, .. .. .	..	22	22
								Long Rough Dab, .. .. .	..	9	9
								Skate, .. .. .	..	46	46
								Angler, .. .. .	..	2	2
									84	146	230	
24. Aberdeen Bay. Between Newburgh and Black Dog.	Nov. 9.	5 to 10	3.0 a.m.	6.20 a.m.	Cod,	3	Offal not recorded.
								Codling,	18	..	..
								Haddock (1),	27	..	..
								" (2),	18	..	..
								" (3),	8	..	..
								— 53	..	..	..
								Plaice (2),	11	..	..
								" (3),	17	..	..
								— 28	..	..	..
								Com. Dab,	13	..	..
									115	..	..
25. Aberdeen Bay. Off Collieston.	"	47.0	49.0	50.0	4½ to 12	6.45 a.m.	11.10 a.m.	Cod,	10	..	10	Moderate breeze ; sea choppy ; rain.
								Codling,	57	..	57	
								Haddock (1),	190	..	..
								" (2),	50	..	..
								" (3),	27	..	..
								— 267	..	11	278	
								Whiting, .. .. .	..	47	47
								Plaice (2),	64	..	..
								" (3),	39	..	..
								— 103	..	..	103
								Com. Dab, .. .. .	..	20	20
								Long Rough Dab, .. .. .	..	13	13
								Skate, .. .. .	..	64	64
								Angler, .. .. .	..	1	1
									437	156	593	
26. Aberdeen Bay. Between Black Dog and Collieston.	"	7½ to 12	11.45 a.m.	3.50 p.m.	Cod,	14	..	14	
								Codling,	28	2	30	
								Haddock (1),	104	..	..
								" (2),	34	..	..
								— 138	..	13	151	
								Whiting, .. .. .	..	38	38
								Coal-fish,	1	..	1	
								Halibut,	1	..	1	
								Plaice (2),	73	..	..
								" (3),	29	..	..
								— 102	..	..	102
								Com. Dab, .. .. .	..	20	20
								Long Rough Dab, .. .. .	..	5	5
								Skate, .. .. .	..	53	53
									284	131	415	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Burghead Bay.	1904. Nov. 21.	..	48	50	10 to 15	12.45 p.m.	4.0 p.m.	Cod,	1	..	1	Wind and rain.
								Haddock, .. ..	..	28	28	
								Whiting, .. ..	..	11	11	
								Brill,	7	..	7	
								Plaice (1), ..	6	..	..
								" (2),	179	..	..
								" (3),	220	..	..
									405	..	405	
								Com. Dab, ..	8	..	8	
								Skate, .. ..	..	2	2	
									421	41	462	
"	"	..	..	..	7 to 25	5.0 p.m.	8.50 p.m.	Codling, .. ..	..	8	8	
								Haddock, .. ..	..	20	20	
								Whiting, .. ..	..	25	25	
								Grey Gurnard, ..	..	31	31	
								Turbot,	4	..	4	
								Brill,	12	..	12	
								Plaice (1), ..	7	..	..
								" (2),	335	..	..
								" (3),	730	..	..
									1072	..	1072	
								Lemon Dab, ..	7	..	7	
								Com. Dab, ..	34	150	184	
								Skate,	16	..	16	
								Angler, .. ..	..	6	6	
									1145	240	1385	
"	Nov. 21 and 22.	..	..	..	5 to 7	9.15 p.m.	1.20 a.m.	Codling, .. ..	..	2	2	
								Haddock, .. ..	..	43	43	
								Whiting, .. ..	..	33	33	
								Grey Gurnard, ..	..	40	40	
								Turbot,	2	..	2	
								Brill,	5	..	5	
								Plaice (2), ..	361	..	..
								" (3),	652	..	..
									1013	19	1032	
								Lemon Dab, ..	3	..	3	
								Com. Dab, ..	20	120	140	
								Skate,	5	..	5	
								Angler, .. ..	..	2	2	
									1048	259	1307	
Burghead, E.S.E.	Nov. 22.	..	..	..	10	1.45 a.m.	5.0 a.m.	Cod,	3	..	3	
								Codling, .. ..	..	19	19	
								Grey Gurnard, ..	..	45	45	
								Halibut,	1	..	1	
								Brill,	13	..	13	
								Plaice (1), ..	8	..	..
								" (2),	399	..	..
								" (3),	704	..	..
									1111	25	1136	
								Lemon Dab, ..	1	..	1	
								Witch,	5	..	5	
								Com. Dab, ..	61	200	261	
								Skate, .. ..	..	3	3	
								Angler, .. ..	..	6	6	
									1195	298	1493	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Witch Grounds. Off Cromarty.	1904. Nov. 23.	..	..	..	27 to 29½	11.30 a.m.	12.40 p.m.	Cod, Codling, Haddock, Whiting, Grey Gurnard, Turbot, Plaice (2), Witch, Lemon Dab, Com. Dab, Long Rough Dab, Skate,	2 2 7 52 2 2	.. 9 21 103 7 40 63 ..	2 9 21 103 7 2 7 52 2 40 63 2	N.N.E. strong breeze; snow showers; sea rough.
									67	243	310	
Burghead Bay.	Nov. 24.	..	48.0	50.0	7 to 19	8.10 a.m.	12.40 p.m.	Cod, Codling, Coal-fish, Haddock (2), Whiting, Grey Gurnard, Turbot, Brill, Plaice (1), " (2), " (3), Com. Dab, Angler,	2 2 1 5 1 11 14 458 445 917 .. ..	.. 4 .. 150 23 8 14 1	2 6 1 155 23 8 11 917 14 1	
									939	200	1139	
"	"	..	..	..	6 to 20	1.5 p.m.	5.15 p.m.	Codling, Haddock (2), Whiting, Brill, Plaice (1), " (2), " (3), Com. Dab, Angler,	3 7 .. 6 8 445 509 962 20 ..	6 10 13 20 2	9 17 13 6 962 40 2	Wind N.N.E.; strong breeze; sea rough.
									998	51	1049	
"	"	..	48.2	50.4	5 to 19	6.0 p.m.	10.15 p.m.	Cod, Codling, Haddock, Grey Gurnard, Halibut, Turbot, Brill, Plaice (1), " (2), " (3), Lemon Dab, Black Sole, Witch, Com. Dab, Skate, Angler,	4 1 2 28 14 503 546 1063 1 1 12 85 2 ..	.. 3 40 5 29 4 3	4 3 40 5 1 2 28 1063 1 1 12 114 6 3	Cod end slightly split. This haul was mostly worked in 5 to 6 fathoms.
									1199	84	1283	

Part III.—Twenty-third Annual Report

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Burghead Bay.	1904. Nov. 25.	5 to 12	3.45 a.m.	8.0 a.m.	Cod,	8	..	8	W.S.W. gentle breeze; sea rough.
								Codling,	7	2	9	
								Haddock, .. .. .	..	19	19
								Whiting, .. .. .	..	14	14
								Grey Gurnard, .. .. .	..	7	7
								Turbot,	7	..	7	
								Brill,	18	..	18	
								Plaice (1),	10	..	..
								" (2),	595	..	..
								" (3),	528	..	..
								—1133	..	..	1133
								Lemon Dab,	5	..	5	
								Witch,	1	..	1	
								Com. Dab,	83	31	114	
								Angler, .. .. .	..	4	4
								—	1262	77	1339	Wind W.S.W.; moderate breeze; sea smooth; rain.
Dornoch Firth.	"	..	..	..	6 to 10	11.30 a.m.	12.30 p.m.	Cod,	1	..	1
								Codling,	1	8	9	
								Haddock (1),	32	..	..
								" (2),	25	..	..
								—57	..	4	61	
								Whiting, .. .. .	..	31	31
								Plaice (2),	57	..	..
								" (3),	67	..	..
								" (4),	89	..	..
								—213	..	16	229	
								Com. Dab,	12	50	62	
								Thornback, .. .. .	..	3	3
								—	284	112	396	
"	"	8	5.0 p.m.	9.0 p.m.	Cod,	5	..	5	Weather fine.
								Codling,	6	2	8	
								Coal-fish,	1	..	1	
								Haddock (1),	191	..	..
								" (2),	141	..	..
								—332	..	16	348	
								Halibut,	1	..	1	
								Turbot,	2	..	2	
								Plaice (1),	4	..	..
								" (2),	369	..	..
								" (3),	240	..	..
								" (4),	631	..	..
								—1244	..	8	1252	
								Lemon Dab,	3	..	3	
								Com. Dab, .. .. .	..	30	30
								—	1594	56	1650	Burghead Bay.
Burghead Bay.	Nov. 26.	..	..	..	6 to 19	5.0 a.m.	9.30 a.m.	Codling, .. .. .	..	7	7
								Haddock, .. .. .	..	15	15
								Whiting, .. .. .	..	22	22
								Grey Gurnard, .. .. .	..	1	1
								Turbot,	2	..	2	
								Brill,	17	..	17	
								Plaice (1),	12	..	..
								" (2),	417	..	..
								" (3),	385	..	..
								" (4),	43	..	..
								—857	..	..	857
								Witch,	2	..	2	
								Lemon Dab,	2	..	2	
								Com. Dab,	37	50	87	
								Skate,	5	..	5	
								—	922	95	1017	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Burghhead Bay.	1904. Nov. 26.	..	..	..	16 to 20	3.20	7.40	Cod,	1	..	1	
								Codling, .. ..	..	8	8	
								Haddock, .. ..	..	15	15	
								Whiting, .. ..	..	19	19	
								Grey Gurnard, .. ..	..	7	7	
								Halibut,	1	..	1	
								Turbot,	1	..	1	
								Brill,	4	..	4	
								Plaice (1),	12	..	..
								" (2),	418	..	..
								" (3),	371	..	..
								" (4),	70	..	..
								—871	..	12	883	
								Lemon Dab,	1	..	1	
								Com. Dab,	30	30	60	
								Long Rough Dab, .. ..	..	10	10	
								Angler, .. ..	..	3	3	
									909	104	1013	
"	Nov. 26 and 27	..	..	..	6 to 15	8.15 p.m.	12.30 a.m.	Cod,	4	..	4	Worked mostly in 6 to 7 fathoms.
								Codling, .. ..	..	3	3	
								Haddock, .. ..	..	23	23	
								Whiting, .. ..	..	10	10	
								Grey Gurnard, .. ..	..	2	2	
								Plaice (Medium),	7 bsks.	..	..
								" (Small),	2	..	..
								
								9 bsks.	..	..	..
								Com. Dab, .. ..	..	41	41	
								Long Rough Dab, .. ..	..	7	7	
								Angler .. ..	..	5	5	
								
Aberdeen Bay.	Nov. 28.	..	..	..	19 to 21	10.0 a.m.	11.15 a.m.	Codling, .. ..	..	11	11	
								Haddock,	11	19	30	
								Whiting, .. ..	..	31	31	
								Plaice (2),	6	..	6	
								Lemon Dab,	1	..	1	
									18	61	79	
Burghhead Bay.	Dec. 6.	43°5	45°0	45°3	4½ to 16	2.0 p.m.	6.0 p.m.	Cod,	8	..	8	
								Codling,	6	27	33	
								Haddock, .. ..	..	20	20	
								Whiting, .. ..	..	18	18	
								Grey Gurnard, .. ..	..	7	7	
								Turbot,	4	..	4	
								Brill,	21	..	21	
								Plaice (1),	18	..	..
								" (2),	272	..	..
								" (3)	448	..	..
								—738	..	9	747	
								Lemon Dab,	2	1	3	
								Com. Dab,	70	57	127	
								Long Rough Dab, .. ..	..	9	9	
								Herring, .. ..	..	5	5	
								Cottus scorpius, .. ..	..	1	1	
								Sandy Ray, .. ..	..	2	2	
								Angler, .. ..	..	2	2	
									849	158	1007	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Burghead Bay.	1904. Dec. 6.	..	..	..	4½ to 16	6 32	10.47	Cod,	18	..	18	
								Codling,	6	7	13	
								Haddock,	1	6	7	
								Whiting, .. ..	..	32	32	
								Car-fish,	1	..	1	
								Grey Gurnard, ..	..	7	7	
								Turbot,	2	..	2	
								Brill,	13	..	13	
								Plaice (1),	11	..	..
								" (2),	291	..	..
								" (3),	551	..	..
								—853	..	..	853	
								Com. Dab,	45	89	134	
								Angler, .. ..	..	1	1	
									939	142	1081	
"	Dec. 7.	..	..	..	6 to 9	3.35 a.m.	7.45 a.m.	Cod,	12	..	12	
								Codling,	8	31	39	
								Haddock (2), ..	6	26	32	
								Whiting, .. ..	..	12	12	
								Brill,	10	..	10	
								Plaice (1),	12	..	..
								" (2),	318	..	..
								" (3),	530	..	..
								—860	..	..	860	
								Lemon Dab,	2	..	2	
								Com. Dab,	51	65	116	
								Long Rough Dab,	..	12	12	
								Sandy Ray,	1	9	10	
								Herring, .. ..	..	1	1	
								Angler, .. ..	..	14	14	
									950	170	1120	
"	"	..	..	..	7½ to 20	8.5 a.m.	12.10 p.m.	Cod,	1	..	1	
								Codling, .. ..	..	5	5	
								Haddock, .. ..	..	21	21	
								Whiting, .. ..	..	7	7	
								Grey Gurnard, ..	..	1	1	
								Turbot,	2	..	2	
								Brill,	19	..	19	
								Plaice (1),	5	..	..
								" (2),	321	..	..
								" (3),	497	..	..
								—823	..	..	823	
								Lemon Dab,	1	..	1	
								Witch,	5	..	5	
								Com. Dab,	46	14	60	
								Long Rough Dab,	..	1	1	
								Sandy Ray, .. ..	..	3	3	
								Angler, .. ..	..	4	4	
									897	56	953	
"	"	38.3	44.2	45.5	7½	1.43 p.m.	2.43 p.m.	Codling, .. ..	..	3	3	Small-meshed net experiment
								Whiting, .. ..	..	2	2	
								Brill,	2	..	2	
								Plaice (1),	2	..	..
								" (2),	56	..	..
								" (3),	118	..	..
								—176	..	..	176	
								Com. Dab,	2	14	16	
								Sandy Ray, .. ..	..	2	2	
								Herring, .. ..	..	5	5	
								Sprat, .. ..	..	1	1	
								Sand-eel, .. ..	..	1	1	
									180	28	208	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over-board.	Total No.	
Dornoch Firth.	1904. Dec. 7.	..	..	..	4 to 9	6.50 p.m.	7.50 p.m.	Cod,	1	..	1	
								Codling,	1	2	3	
								Haddock (2),	18	..	18	
								Whiting,	1	12	13	
								Plaice (2),	75	..	..
								" (3),	74	..	..
								.. ..	—149	7	156	
								Lemon Dab,	2	6	8	
								Thornback Ray,	6	7	13	
								Solenette, .. ..	..	1	1	
									178	35	213	
"	Dec. 7. and 8.	..	..	..	8 to 12	8.20 p.m.	12.40 a.m.	Codling,	2	2	2	
								Haddock (1),	105	..	..
								" (3),	—107	10	117	
								Whiting, .. ..	..	4	4	
								Plaice (2),	171	..	..
								" (2),	197	..	..
								" (3), .. ..	..	..	..
								" (4),	314	..	..
								.. ..	—682	55	737	
								Lemon Dab (1),	1	..	1	
								Megrim (1),	1	..	1	
								Com. Dab,	17	43	60	
								Thornback Ray,	3	9	12	
									811	123	934	
Burghead Bay.	Dec. 9.	..	..	..	5½ to 9	4.20 p.m.	8.30 p.m.	Codling, .. ..	..	27	27	
								Haddock (1),	1	..	..
								" (2),	5	..	..
								" (4),	9	..	..
								.. ..	15	..	15	
								Whiting, .. ..	..	7	7	
								Turbot,	3	..	3	
								Brill,	13	..	13	
								Plaice (1),	2	..	..
								" (2),	284	..	..
								" (3),	254	..	..
								" (4),	67	..	..
								.. ..	—607	6	613	
								Witch,	2	..	2	
								Com. Dab,	60	97	157	
								Flounder,	1	..	1	
								Thornback, .. ..	..	1	1	
									701	138	839	
"	Dec. 9 and 10.	..	..	..	6 to 9	8.40 p.m.	12.45 a.m.	Cod,	4	..	4	
								Codling,	2	23	25	
								Haddock (1),	2	9	11	
								Whiting, .. ..	..	13	13	
								Brill,	9	..	9	
								Plaice (1),	3	..	..
								" (2),	316	..	..
								" (3),	278	..	..
								" (4),	17	..	..
								.. ..	—614	..	614	
								Com. Dab,	84	132	216	
								Angler, .. ..	..	2	2	
									715	179	894	

Part III.—Twenty-third Annual Report

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Burghead Bay.	1904. Dec. 1 ^o .	42.1	44.4	45.5	4½ to 8	7.30 a.m.	11.30 a.m.	Cod,	3	..	3	
								Codling,	3	4	7	
								Haddock, .. .. .	..	8	8	
								Whiting, .. .. .	..	11	11	
								Brill,	8	..	8	
								Plaice (1),	1	..	..
								" (2),	250	..	..
								" (3),	260	..	..
								" (4),	38	..	..
								—549	4	..	553	
								Lemon Dab,	1	..	1	
								Com. Dab,	24	15	39	
								Flounder,	1	..	1	
									589	42	631	
"	"	"	"	"	6 to 9	12.10 p.m.	4.30 p.m.	Cod,	7	..	7	Wind W.S.W.; light breeze; sea smooth. Net split.
								Codling,	2	3	5	
								Haddock, .. .. .	..	9	9	
								Brill,	12	..	12	
								Plaice (2),	202	..	..
								" (3),	103	..	..
								" (4),	29	..	..
								—334	5	..	339	
								Com. Dab,	5	17	22	
									360	34	394	
"	"	"	"	"	6½ to 9	5.0 p.m.	9.5 p.m.	Cod,	10	..	10	Net slightly split.
								Codling,	7	15	22	
								Haddock (2),	6	11	17	
								Whiting, .. .. .	..	31	31	
								Coal-fish,	1	..	1	
								Halibut,	1	..	1	
								Turbot,	1	..	1	
								Brill,	16	..	16	
								Plaice (1),	4	..	..
								" (2),	328	..	..
								" (3),	343	..	..
								" (4),	104	..	..
								—779	13	..	792	
								Lemon Dab,	2	..	2	
								Com. Dab,	72	47	119	
								Long Rough Dab, .. .. .	..	4	4	
								Angler, .. .. .	..	9	9	
								Thornback, .. .. .	..	2	2	
									895	132	1027	
"	"	"	"	"	6 to 9	5.40 p.m.	10.10 p.m.	Cod,	5	..	5	
								Codling,	2	11	13	
								Haddock, .. .. .	..	8	8	
								Whiting, .. .. .	..	12	12	
								Brill,	4	..	4	
								Plaice (2),	230	..	..
								" (3),	263	..	..
								" (4),	109	..	..
								—602	9	..	611	
								Com. Dab,	50	34	84	
								Long Rough Dab, .. .. .	..	1	1	
								Thornback, .. .. .	..	3	3	
								Angler, .. .. .	..	5	5	
									663	83	746	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Burghead Bay.	1904. Dec. 11.	9 to 12	8.0 a.m.	12 noon	Cod,	3	..	3	N.E. strong breeze; rain; sea rough.
								Codling,	1	16	17	
								Haddock,	12	19	31	
								Whiting, .. ..	..	3	3
								Turbot,	3	..	3	
								Brill,	9	..	9	
								Plaice (1),	4	..	..
								" (2),	354	..	..
								" (3),	207	..	..
								" (4),	30	..	..
								—595	..	4	599	
								Witch,	10	..	10	
								Com. Dab,	21	42	63	
								Long Rough Dab, .. ..	..	5	5
								Angler, .. ..	..	4	4
								—	654	93	747	
Dornoch Firth.	"	8 to 12	1.40 p.m.	6.40 p.m.	Cod,	2	..	2	Strong breeze from N.E.
								Codling,	4	22	26	
								Haddock (1),	2	..	..
								" (3),	5	..	..
								—7	..	..	7
								Whiting, .. ..	..	9	9
								Grey Gurnard, .. ..	..	3	3
								Plaice (2),	160	..	..
								" (3),	227	..	..
								" (4),	326	..	..
								—713	..	33	746	
								Com. Dab,	16	39	55	
								Thornback Ray, .. ..	..	2	2
								—	742	108	850	
Smith Bank.	Dec. 12.	19 to 22	11.5 a.m.	12.5 p.m.	Codling,	1	..	1	Small-meshed net on cod end.
								Brill,	1	..	1	
								Plaice (2),	26	..	26	
								—	28	..	28	
Aberdeen Bay. Off Quarries.	Dec. 13.	17 to 19	10.30	11.30	Cod,	6	..	6	Small-meshed net over cod end; N.E. strong breeze; sea rough; and heavy rain.
								Codling,	54	..	54	
								Whiting, .. ..	..	10	10
								Plaice (2),	33	..	..
								" (3),	8	..	..
								—41	..	..	41
								Com. Dab, .. ..	..	8	8
								Long Rough Dab, .. ..	..	1	1
								Grey Skate,	2	4	6	
								Thornback, .. ..	..	17	17
								—	103	40	143	
"	"	41.2	43.2	48.0	"	12.35 p.m.	4.40 p.m.	Cod,	19	..	19	
								Codling,	24	5	29	
								Halibut,	2	..	2	
								Plaice (2),	53	..	..
								" (3),	20	..	..
								—78	..	..	78
								Com. Dab,	12	16	28	
								Long Rough Dab, .. ..	..	9	9
								Thornback, .. ..	..	16	16
								Angler,	1	..	1	
								—	136	46	182	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Faerøe. Fuglø, bearing N.W.	1904. Apr. 24.	55 to 73	4.20 a.m.	8.20 a.m.	Cod,	5	..	5	Stormy.
								Codling,	520	..	520	
								Haddock (1), ..	190	..	..
								" (2),	42	..	..
								" (3),	168	..	..
								—400	..	..	400
								Ling,	1	..	1	
								Tusk,	1	..	1	
								Cat-fish,	21	..	21	
								Halibut,	16	..	16	
								Plaice (1), ..	8	..	..
								" (2),	1	..	..
								—9	..	..	9
								Lemon Dab, ..	30	..	30	
								Com. Dab, ..	33	2	35	
								Long Rough Dab,	..	1	1	
								Thornback, ..	8	..	8	
								Angler,	1	..	1	
								—	1045	3	1048	
Fuglø, N.W. by W.	"	53 to 73	8.50 a.m.	12.50 p.m.	Cod,	1	..	1	Stormy ; net split.
								Codling,	1 b	skt.	..	
								Haddock (1), ..	656	..	..
								" (2),	49	..	..
								" (3),	200	..	..
								—905	..	1	906	
								Ling,	1	..	1	
								Cat-fish,	11	..	11	
								Halibut,	4	..	4	
								Plaice (1), ..	18	..	18	
								Lemon Dab, ..	28	..	28	
								Com. Dab, ..	27	10	37	
								Long Rough Dab,	..	1	1	
								Thornback, ..	3	1	4	
								Angler,	4	2	6	
								—	
Fuglø, bearing N.W. by W.	"	53 to 57	1.40 p.m.	5.40 p.m.	Cod,	2	..	2	Stormy ; tow-net torn to pieces.
								Codling,	50	..	50	
								Haddock (1), ..	496	..	..
								" (2),	41	..	..
								" (3),	241	..	..
								—778	..	..	778
								Coal-fish, ..	1	..	1	
								Cat-fish,	11	..	11	
								Halibut,	6	..	6	
								Plaice (1), ..	7	..	7	
								Lemon Dab, ..	15	..	15	
								Com. Dab, ..	1	23	24	
								Angler,	3	1	4	
								—	874	24	898	
Fuglø, W.N.W.	"	57	6.5 p.m.	10.5 p.m.	Cod,	86	Stormy ; net split.
								Codling,	9 b	schts.	..	
								Haddock (1), ..	595	..	..
								" (2),	1 b	scht.	..	
								" (3),	103	..	..
								—	
								Ling,	15	..	..
								Tusk,	2	..	..
								Coal-fish, ..	6	..	..
								Cat-fish,	8	..	..
								Halibut,	12	..	..
								Plaice (1), ..	51	..	..
								Lemon Dab, ..	7	..	..
								Com. Dab, ..	..	9	..
								Angler, .. ..	..	1	..
								—	

TRAWLING INVESTIGATIONS—TABLE I

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Fuglö, W.N.W.	1904. Apr. 24 and 25.	..	..	..	57 to 65	11.5 p.m.	3.5 m	Cod, Codling, Haddock (1), " (2), " (3), —138 Coal-fish, Cat-fish, Halibut, Plaice (1), Lemon Dab, 176 176	7 11 106 9 23 —138 1 1 5 3 10	.. .. .. .. .. .. .. .. .. .. ..	7 11 138 1 1 5 3 10	Cod-end gave way; most of fish lost; no offal.
Færøe.	Apr. 25.	..	..	..	63	3.5 a.m.	7.0 a.m.	Cod, Codling, Haddock (1), " (2), " (3), —17½ Ling, Coal-fish, Halibut, Plaice (1), 1½ b skt.	200 4 b 15 bskts. 1 1½ —17½ 3 17 8 1½ b	.. skts. skt. ..	.. .. .. .. .. .. .. .. .. .. ..	Strong wind; weather stormy; split net.
"	"	..	..	..	"	7.40 a.m.	12 noon.	Cod, Codling, Haddock, Ling, Cat-fish, Halibut, Plaice (1), " (2), —8 Lemon Dab, Com. Dab, Thornback, Angler, 580 594	1 166 362 5 10 6 7 1 —8 14 .. 2 6	.. .. .. .. .. .. .. .. .. 13 1 ..	1 166 362 5 10 6 .. 8 14 13 3 6	Wind and snow.
Fuglö, N.N.W.	"	..	..	..	63 to 71	12.40 p.m.	5.40 p.m.	Haddock (1), " (3), —2 Cat-fish, Halibut, Plaice (1), Lemon Dab, Angler,	1 bskt. 1 —2 5 3 3 5 1 ..	.. .. .. .. .. .. .. .. ..	.. .. .. .. .. .. .. .. ..
15 miles N.W. Viderö.	Apr. 26.	..	..	..	60 to 67	11.30 a.m.	1.30 p.m.	Cod, Haddock (1), " (2), " (3), —13 Ling, Com. Dab, Angler, 19 19	3 7 2 4 —13 1 1 1	.. .. .. .. .. .. .. ..	3 13 1 1 1	Heavy swell; wind N.N.W.; very stormy; net split.

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Shot.	Hauled.	Fish Caught.				Remarks.
		Air.	Surface.	Bottom.				Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
N. W. Viderö.	1904. Apr. 26.	60 to 69	2.15 p.m.	6.15 p.m.	Haddock (1), ..	170	Strong wind and heavy swell.
								" (3), ..	17	..	..
								Ling, ..	— 187	..	187	
								Halibut, ..	2	..	2	
								Lemon Dab, ..	4	..	4	
								Angler, ..	7	..	7	
									2	..	2	
									202	..	202	
Fuglö, bearing N.W.	Apr. 26 and 27.	48 to 49	9.15 p.m.	12.15 a.m.	Cod, ..	70	..	70	Blowing a gale from west.
								Codling, ..	264	..	264	
								Haddock (1), ..	168	..	..
								" (2), ..	21	..	..
								" (3), ..	53	..	..
									— 242	..	242	
								Coal-fish, ..	8	..	8	
								Cat-fish, ..	15	..	15	
								Halibut, ..	13	1	14	
								Plaice (1), ..	7	..	..
								" (2), ..	1	..	..
									— 8	..	8	
								Lemon Dab, ..	11	3	14	
								Com. Dab, ..	..	7	7
								Thornback, ..	..	2	2
									631	13	644	
"	Apr. 27.	48 to 59	12.50 a.m.	4.50 a.m.	Codling, ..	152	..	152	Very stormy.
								Haddock (1), ..	198	..	..
								" (2), ..	31	..	..
								" (3), ..	58	..	..
									— 287	..	287	
								Coal-fish, ..	15	..	15	
								Cat-fish, ..	7	..	7	
								Halibut, ..	10	..	10	
								Plaice (1), ..	13	..	13	
								Lemon Dab, ..	29	1	30	
								Com. Dab, ..	..	5	5
								Starry Ray, ..	1	2	3	
								Angler, ..	..	1	1
									514	9	523	
Fuglö, N.W.	"	48 to 63	5.15 a.m.	9.15 a.m.	Cod, ..	2	..	3	Stormy.
								Codling, ..	484	..	484	
								Haddock (1), ..	1034	..	..
								" (2), ..	33	..	..
								" (3), ..	86	..	..
									— 1153	..	1153	
								Coal-fish, ..	3	..	3	
								Cat-fish, ..	5	..	5	
								Halibut, ..	5	..	5	
								Plaice (1), ..	9	..	9	
								Lemon Dab, ..	7	..	7	
								Com. Dab, ..	24	..	24	
								Angler, ..	..	2	2
									1693	2	1695	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Fuglö, bearing N.W.	1904. Apr. 27.	..	..	..	63	11.0 a.m.	3.0 p.m.	Cod, Codling, Haddock (1), .. " (2), .. " (3), .. —1017 Coal-fish, Cat-fish, Halibut, Plaice (1), " (2), —11 Lemon Dab, Com. Dab, Thornback, Starry Ray, Angler, 1238	18 148 902 33 82 8 13 7 9 2 7 2 1 1 4	.. .. .. .. .. .. .. .. .. .. 1 12 3	18 148 1017 8 13 7 11 8 14 2 1 7	Stormy.
"	"	..	..	..	63 to 75	3.20 p.m.	7.20 p.m.	Haddock (1), .. " (3), .. —189 Halibut, Plaice (1), Lemon Dab, Com. Dab, Angler, 196	123 66 1 1 3 .. 2	.. .. .. .. .. 3 ..	.. .. 189 1 3 3 2	Stormy; split net; two tow-nets at- tached to warps.
"	"	..	..	..	73 to 75	7.55 p.m.	11.55 p.m.	Cod, Codling, Haddock (1), .. " (2), .. " (3), .. —637 Tusk, Ling, Whiting, Cat-fish, Halibut, Turbot, Plaice (1), " (2), —23 Lemon Dab, Megrim, Com. Dab, Thornback, Grey Skate, Angler, 919	29 144 432 56 149 1 6 5 18 8 4 21 2 23 30 1 .. 6 2 5	.. .. .. .. .. .. .. .. .. .. .. .. .. 1 12 17 .. 2	29 144 637 1 6 5 18 8 4 23 31 1 12 23 2 7	Weather stormy.
"	Apr. 28.	..	..	..	65 to 73	12.25 a.m.	4.25 a.m.	Cod, Codling, Haddock (1), .. " (2), .. " (3), .. —1038 Coal-fish, Cat-fish, Halibut, Plaice (1), " (2), —9 Lemon Dab, Com. Dab, Thornback, Angler, 1312	55 108 957 32 40 1038 17 15 18 7 2 9 23 13 7 4	.. .. .. .. .. .. .. .. .. .. .. .. 4 6 9 1	55 108 1038 17 15 18 9 32 19 16 5	Stormy.
									1312	20	1332	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Fuglö, bearing N.W.	1904. Apr. 28.	65	4.55 a.m.	8.55 a.m.	Cod,	4	..	4	Wind S.S.E.
								Codling,	111	..	111	
								Haddock (1),	154	..	..
								" (2),	11	..	..
								" (3),	194	..	..
								—359	..	..	359
								Coal-fish,	2	..	2	
								Cat-fish,	13	..	13	
								Halibut,	3	..	3	
								Plaice (1),	11	..	11	
								Lemon Dab,	15	..	15	
								Thornback,	1	..	1	
								Angler,	1	1	2	
									520	1	521	
"	"	58 to 63	9.50 a.m.	10.20 a.m.	Cod,	1	..	1	Heavy swell ; small- meshed net.
								Codling,	48	..	48	
								Haddock (1),	20	..	..
								" (2),	7	..	..
								" (3),	22	..	..
								—49	..	..	49
								Cat-fish,	2	..	2	
								Halibut,	1	..	1	
								Plaice (1),	2	..	2	
								Lemon Dab,	3	..	3	
								Com. Dab,	7	..	7	
								Thornback,	1	..	1	
									114	..	114	
"	"	63 to 65	11.0 a.m.	3.0 p.m.	Cod,	160	..	160	Heavy swell.
								Codling,	112	..	112	
								Haddock (1),	267	..	..
								" (2),	71	..	..
								" (3),	215	..	..
								—553	..	..	553
								Coal-fish,	5	..	5	
								Cat-fish,	7	..	7	
								Halibut,	8	..	8	
								Plaice (1),	5	..	5	
								Lemon Dab,	5	..	5	
								Skate,	3	..	3	
								Angler,	4	..	4	
									862	..	862	
"	"	54 to 65	3.30 p.m.	7.30 p.m.	Cod,	1	..	1	Heavy sea running.
								Codling,	144	..	144	
								Haddock (1),	138	..	..
								" (2),	25	..	..
								" (3),	238	..	..
								—401	..	..	401
								Coal-fish,	3	..	3	
								Cat-fish,	7	..	7	
								Halibut,	8	..	8	
								Plaice (1),	9	..	..
								" (2),	1	..	..
								—10	..	..	10
								Lemon Dab,	16	..	16	
								Skate,	2	..	2	
								Angler,	4	2	6	
									596	2	598	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Fuglō, bearing N.W.	1904. Apr. 28 and 29.	..	..	..	54 to 62	8.15 p.m.	12.15 a.m.	Cod, Codling, Haddock (1), " (2), " (3), Tusk, Cat-fish, Plaice, Lemon Dab, Angler,	61 144 190 73 85 —348 1 9 9 11 2	.. .. .. .. .. .. .. .. .. ..	61 144 348 1 9 9 11 2	Very stormy; wind S.E.; net split.
									585	..	585	
"	Apr. 29.	..	..	..	"	1.35 a.m.	5.35 a.m.	Cod, Codling, Haddock (1), " (2), " (3), Coal-fish, Cat-fish, Halibut, Plaice, Lemon Dab, Com. Dab, Angler, Dog-fish,	55 134 272 11 29 —312 3 4 3 4 29 .. .. ..	.. .. .. .. .. .. .. 3 6 3 4	55 134 312 3 4 3 4 32 6 3 4	Blowing a gale.
									544	16	560	
"	"	..	..	..	54 to 75	6.15 a.m.	10.15 a.m.	Codling, Haddock (1), " (2), " (3), Cat-fish, Halibut, Plaice, Lemon Dab, Dog-fish, Angler,	3 78 9 27 —114 10 3 2 5 .. ..	.. .. .. .. .. .. .. 8 1	3 114 10 3 2 5 8 1	Heavy swell.
									137	9	146	
Fuglō, bearing W.N.W.	"	..	..	..	56 to 75	10.40 a.m.	2.40 p.m.	Haddock (1), " (2), " (3), Coal-fish, Cat-fish, Halibut, Plaice (1), " (2), Lemon Dab, Starry Ray, Angler,	41 4 9 —54 9 7 1 7 2 9 3 1 1	.. .. .. .. .. .. .. .. .. .. ..	.. .. .. 54 9 7 1 .. 9 3 1 1	S.E. wind.
									85	..	85	
Fuglō, bearing N.W.	"	..	..	..	55 to 60	4.15 p.m.	8.15 p.m.	Cod, Codling, Haddock (1), " (2), " (3), Coal-fish, Cat-fish, Halibut, Plaice (1), Lemon Dab, Angler,	8 160 140 15 88 —243 2 5 3 6 2 1	.. .. .. .. .. .. .. .. .. .. ..	8 160 243 2 5 3 6 2 1	Stormy.
									430	..	430	

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Fuglö, bearing N.W.	1904. Apr. 29 and 30.	..	..	..	55	8.50 p.m.	12.50 a.m.	Cod, 61 Codling, 264 Haddock (1), .. 163 " (2), .. 21 " (3), .. 99 —283 Coal-fish, 5 Cat-fish, 4 Halibut, 34 Plaice (1), .. 27 Lemon Dab, .. 46 Angler, 4 728 4 732	61 264 163 21 99 283 5 4 34 27 46 4	.. .. .. .. .. .. .. .. .. .. 4	61 264 283 5 4 34 27 46 8	
"	Apr. 30	..	..	..	54	1.25 a.m.	3.0 a.m.	Cod, 9 Codling, 100 Haddock (1), .. 71 Coal-fish, 7 Cat-fish, 1 Plaice (1), .. 4 192 .. 192	9 100 71 7 1 4	.. .. .. .. .. ..	9 100 71 7 1 4	Split net; stormy.
"	"	..	..	..	54 to 56	3.30 a.m.	7.30 a.m.	Cod, 5 Codling, 170 Haddock (1), .. 298 " (2), .. 19 " (3), .. 110 —427 Coal-fish, 5 Cat-fish, 11 Halibut, 16 Plaice (1), .. 16 " (2), .. 6 —22 Lemon Dab, .. 23 Com. Dab, .. 16 Thornback, 3 Angler, 2 697 8 705	5 170 298 19 110 427 5 11 16 16 6 22 23 16 .. 2	.. .. .. .. .. .. .. .. .. .. .. .. 5 3 ..	5 170 427 5 11 16 22 23 21 3 2	

II.—A CONTRIBUTION TO THE LIFE-HISTORY OF THE LOBSTER (*HOMARUS VULGARIS*). By H. CHAS. WILLIAMSON, M.A., D.Sc., Marine Laboratory, Aberdeen.

(PLATES I.—IV.)

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EXPERIMENTS IN LOBSTER-CULTURE.

In the summer of 1902 the Fishery Board instructed me to carry out some experiments in the culture of lobsters and crabs. It was intended that the young lobsters hatched out at the Laboratory should be liberated on the north coast of Aberdeenshire, in the neighbourhood of Fraserburgh. In order to obtain a supply of larvæ a number of berried hen lobsters were procured from Girvan and Dunbar in June and July. Eight were sent from Girvan and ten from Dunbar; one was captured in the Bay of Nigg. One of the Dunbar lobsters arrived on August 2nd. The lobsters were conveyed by rail, packed, in some cases, in straw, in other cases in dripping seaweed. The latter method was much the better, the lobsters, after their eight to twelve hours' confinement, being unpacked in a fresh and lively condition. Some of those packed in straw succumbed. In 1904 the stock of berried lobsters were all packed in wet seaweed, and none died in transit.

No special apparatus, with the exception of two tin boxes, was made for the experiment. A temporary arrangement of the hatching apparatus (Dannevig's), used for the eggs of the plaice, proved successful on the whole. The eggs were already far advanced.

An attempt was made to hatch the eggs detached from the parent lobster in one or two cases where the latter had died during transport to Aberdeen. A sheet-iron box, which fitted into one of the compartments of the hatching apparatus, and which was arranged with a perforated bottom through which the water entered, to escape by the top of the box through a grating, was employed; but a considerable death-rate ensued, and the eggs were attacked by a fungus. None of the eggs hatched out. It was decided to allow the eggs to remain attached to the parent until they hatched. All that was necessary then was to keep the adults in a suitable tank and to make arrangements whereby the larvæ, as they hatched out, could be captured and removed to suitable boxes where they would be under control.

Fullarton adopted the method of keeping the berried females in confinement, in an open pond, until the eggs hatched; but in his experiments carried out in 1895 the larvæ were allowed to escape to the sea as they were hatched. In the present case the young lobsters had to be retained. The arrangement was as follows. The berried hens, fourteen in number, were kept in a wooden tank measuring about 8 feet by 4 feet 6 inches by 2 feet deep. The water supply entered at the bottom of the box, and the outflow took place from the surface of the water. The overflow water was led into the hatchery and distributed into the hatching apparatus. As the little lobsters hatched out they were carried down to the hatchery and caught and detained in the hatching boxes.

In order that a large number comparatively of lobsters be kept in a small area, it is necessary that they each be provided with a hole or pen for shelter. The wooden tank in which the adults were confined was prepared in the following manner. A plank of wood about 7 inches wide was hinged by means of large fencing staples to the side of the wooden tank. When horizontal in position it was about 4 or 5 inches above the bottom. The space beneath this shelf was divided off by means of bricks set on edge into as many compartments as were required; in this case seven. The shelf rested on the bricks, and when the tank was filled it was kept down by a suitable weight, some stones or bricks. One shelf was put on each long side. This arrangement permitted of ready examination of the lobsters, as when the superincumbent stones were removed the shelf floated up, revealing the lobsters. They remained there, then, in apparently suitable conditions. Each lobster stuck to its pen, its body hid by the shelf, and its projecting antennæ alone betraying its presence. Only one lobster died from injuries received through fighting with the other inhabitants of the tank. The large chelæ were not tied.

The young hatched out in batches. The eggs of one female do not all hatch simultaneously, but over a period. In two cases recorded by Herrick, a week elapsed from the time the first larva appeared until all were hatched out. Fullarton found the time necessary for hatching a single brood varied from a week to three weeks, or even longer. The aeration of the eggs attached to the abdominal feet of the female is assured in the following manner. The lobster is seen every now and then with its abdomen stretched out to its full extent and resting on the inturned edge of the telson. The swimmerets are meanwhile gently waved backwards and forwards, in this way aerating the eggs and tending to cleanse them. When the eggs are ready to hatch this facilitates the escape of the larvæ. This action was noticed by Coste. The hatching of the lobster eggs at Brodick, Fullarton states, occurred in July, August, and September, with a maximum in August.

The first young lobsters were observed in the Laboratory, Bay of Nigg, on July 11th; they had then reached the hatching apparatus. They apparently hatch during the night, as each morning there was a fresh addition to the stock. The little lobsters were in the first zoëa stage (fig. 66). They were kept in boxes having sieve bottoms, which were placed in the top compartments of a hatching apparatus. They measured about 1 foot by 1 foot by 1 foot, and were painted black. They received light from above only. The number of larvæ kept in one box varied, but not more than twenty were knowingly confined together. They were kept in the top compartments in order that they might obtain a share of the food that was being brought in by the water supply, *e.g.* copepoda, diatoms, and larvæ of invertebrates. The water was not filtered. It flowed into the box by a spout and out by the sieve bottom, the arrangement which is followed in hatching the eggs of plaice and cod.

The lobsters, immediately after being hatched, swam actively about, chasing copepoda and any small white particles moving in the water. The two species of copepods most common in the water were determined by Dr. Scott. A red copepod was *Temera longicornis*; a white one was *Eurytemera affinis*. They were both small.

During the zoëa stages, when the lobster is wholly pelagic, that is to say before the pereopods function as walking legs, a period of, roughly, three weeks, it swims with its body bent in a quadrant shape, having the head and thorax lying horizontal, or inclined slightly downwards, and the abdomen and tail directed downwards. If it spies a copepod beneath it swims directly down for it in a circling, sort of corkscrew path, and follows up its prospective victim, when it escapes with a smart dart off for a distance of an inch or two. The pursuit may last for a little time, and now and then the lobster catches and devours the copepod. When the copepods are swimming above them they also detect them and swim directly for them. They also notice them when in front of them and on the same level. The copepods are to be seen on the side of the box, and the young lobsters go poking about the side after them.

The larval lobster, when undisturbed, swims forward at a uniform speed by means of the exopodites of the pereopods, turning sharply to this side or to that to seize any object that attracts its attention, and which it will pursue till it loses sight of it or has its attention distracted by another form. When surprised it jerks backward by means of its abdomen and telson.

The young lobsters were usually close to the surface of the water. No food was provided regularly for them, except what was brought in with the water supply. On a few occasions a little of the liver of the crab (*Cancer pagurus*) was supplied them. They pursued the little white portions as they fell through the water, usually catching them before they reached the bottom. They ate up the live zoëæ of *Cancer pagurus* when these were poured into the box.

While the lobster in the zoëa stages no doubt eats dead organisms, as Cunningham relates, it is much more active in the pursuit of living animals. It follows, from the fact of its pelagic existence, that it must feed on living forms.

The lobsters were kept for varying periods. When set free they were mostly in the second and third stages; some were in the first stage. A few were reared to the megalops stage on the food in the water supply. The total number set free was about 3000. They were distributed as follows:—

August 6, 1902.—1000 larvæ set free a little over 1 mile north of Fraserburgh.

August 7, 1902.—1000 larvæ set free about $\frac{1}{2}$ mile off Cairnbulg

August 19, 1902.—1000 larvæ set free about $\frac{1}{2}$ mile off St. Combs.

The fry were conveyed in large glass (sulphuric acid) carboys by rail to Fraserburgh. All the lobster fry (1000) were on each occasion stowed in one carboy. The number of fry in the first consignment was counted, and from that datum the numbers in the subsequent lots were deduced.

No special cooling preparations were found to be necessary for the journey. Experiments were made to test the effect of a possible rise in the temperature of the water during the transportation. The temperature of the sea-water in the hatchery was 12.5° C. A few lobster fry were put into a jar containing half-a-gallon ($= \frac{2}{3}$ litre) of water. The jar was heated slowly until the water reached a temperature of 20° C; it was then allowed to cool. Next day the lobsters were, with two exceptions, all lively; two had succumbed.

For the journey to Fraserburgh the larvæ were packed at 3.15 p.m., and were set free at 7.15 p.m., at which time they were all quite lively.

The vitality of the young lobster under certain conditions is remarkable. Herrick kept them alive in small flat dishes, without change of the water, from one to four days at a time, or until they moulted to the second stage. A case in point occurred at the Laboratory. After one of the journeys to Fraserburgh a few larvæ had been left in the dregs of water in one of the carboys. They were discovered 10 days later, and were then alive and active. Two small crabs (*Carcinus maenas*) were kept for a week in a little glass cell without change of water, and apparently suffered no ill-effects.

There was a considerable mortality among the larval lobsters when in the hatchery. As has been so often noted, a proportion of the deaths occurred during moulting. The dead lobsters were sometimes partly eaten. No case was seen of one zoëa attacking and killing another, such as Herrick witnessed. A case of cannibalism was noticed in the megalops stage. One megalops was seen eating the tail of another which was still alive. The telson and part of the abdomen had been eaten off when discovered. A cause of considerable mortality is probably starvation. It is difficult to supply suitable and sufficient food.

All the lobster eggs were hatched out by September 10, 1902.

THE REARING OF LOBSTERS.

There are two well-marked stages in the life of the lobster fry: these are (1) the first swimming stage, when just hatched (fig. 66, pl. iv.), and (2) the stage when it for the first time takes on the form, and, to a certain extent, also the habits, of the adult (fig. 72, pl. iv.). The former is the first zoëa stage, the latter is the megalops stage. Previous to the first zoëa stage there is the protozoëa, a stage of short duration. The lobster has been described as issuing from the egg as a protozoëa. This condition was not observed by the writer. It moults very soon after, and becomes a zoëa of the first stage. R. Q. Couch was the first to figure and describe the protozoëa. He wrote as follows:—"Several of the ripest bunches of ova were taken off, and by gentle agitation many of the young escaped and swam about very freely, like those of the common crab, and some were artificially extracted to leave no doubt to rest on their parentage. Their bodies are large, stout, and of a deep blue colour, while the other parts are semi-transparent and dotted with red. The eyes are large, sessile, situated on a festoon at the lower and anterior margin of the dorsal shield, and marked at the circumference with radiating lines. The interior margin of the shield is waved, and irregularly prominent; the posterior and lateral surfaces are more remarkably so, and are rough, with minute papillary eminences; and the lower margin is marked with seven minute plaited folds, beneath the five central ones are situated five claws on either side. They are jointed as in the adult, and the anterior pair are shorter and stouter than the others, and terminate in a pair of nippers. The tail is longer than the diameter of the body, is extended and composed of five annulations. The termination is forked, but the fork is composed of two flat fan-like expansions separated by a fissure which extends nearly as high up as their articulation."

Saville Kent and Fullarton also give drawings and descriptions of this stage.

The megalops stage is one in which the lobster in its habits resembles more a prawn (*Palæmon*), as Saville Kent pointed out. The interval which exists between the first zoëa and the megalops has been filled in by a varying number of stages. Herrick, for the American lobster,

makes the period one of three zoëa stages, and between hatching and the arrival of the young at the megalops condition there elapses from eight to eighteen days. Saville Kent said that the European lobster reached the megalops stage at about the sixth cast, *i.e.* five stages precede it, viz. the protozoëa and four zoëa stages. A month or six weeks are occupied in arriving at the stage beyond the megalops, which I have denominated the first young stage. My own observations lead to the conclusion that the period just mentioned will very rarely be exceeded; it is probably often as short as one month. Certain larvæ which were in the zoëa condition in October and November remained for five weeks in one stage, however.

Sars illustrates three zoëa stages. Chadwick has published a description of the protozoëa, three zoëa stages, megalops, and first young stages. The time occupied by each stage, with the exception of the protozoëa, is given as a week.

Rathke says the maxillipedes and pereopods have a general resemblance to the legs of schizopods, viz., Mysis, but the resemblance is lost in the fifth pereopod. In the denomination of the larval lobsters it has been customary, therefore, to refer to the early pelagic stage as the "mysis" stage. This is due to the fact that its pereopods resemble those of Mysis, in having setæ-bearing exopodites. But this is an ontogenetic, not a phylogenetic, character, as the name is apt to imply. The main swimming organ of a zoëa is the exopodite, and the number of setose exopodites is directly proportional to the size of the larva. The little elongated zoëa of the shrimp (*Crangon vulgaris*) has three pairs of exopodites in its first stage, but its increase in bulk in the third zoëa stage demands additional swimming power, and a fourth pair of exopodites appear, viz. attached to the rudimentary first pereopod.* In this case the exopodite is developed, and becomes functional in the third zoëa stage, whereas the chela becomes functional for the first time on the megalops stage, *i.e.* the sixth larval stage. The exopodite of the chela at the same time vanishes, while the other exopodites, those of the maxillipedes, are reduced and function no longer for swimming. In the case of the lobster larva we have to deal with a large form, which requires a powerful swimming organ. That is secured by the development of the exopodites on the pereopods, but with this difference from the shrimp, that the pereopods themselves are also functionally developed—in the form of maxillipedes. The zoëa of the lobster is provided, then, with eight maxillipedes, each of which has a setose exopodite. On the arrival of this form at the megalops stage the latter disappear or are so reduced that they are no longer swimming organs. The quadrant shape in which the body of the zoëa is bent, by concentrating the weight of the animal, has a direct relation to its propelling organs. The tiny zoëa of *Carcinus mænas* has only two pairs of exopodites. It is bent in an arc; thereby the weight is concentrated.

There, appears, then to be no valid reason for departing from the term "zoëa" for this period of the life of the lobster. And the term "megalops" is an appropriate name for the stage which is analogous as well as homologous to the megalops of the Brachyura. It is a transition stage between the zoëa and the adult.

In this country the rearing of lobsters has been carried out by Saville Kent, Cunningham, Weldon, Fowler, and Chadwick. On the Continent Captain Dannevig has done the most extensive work in this subject; lately Appellöf has carried on rearing experiments.

Many difficulties meet the experimenter in lobster-culture. Questions of the food, of the cannibalism of the larvæ, and of the mortality which

* *Vide* Williamson.

occurs during moulting all arise. Saville Kent kept the little lobsters in jars and fed them with a little minced fish; the water was changed every day. Receptacles on the intermittent syphon system were, he considered, especially well suited for lobster-rearing. Weldon and Fowler used for the food of the larvæ the yolk of a hard-boiled egg, crushed crab (*Carcinus mænas*, *Portunus depurator*), boiled liver, the contents of the tow net (at that period chiefly *Noctiluca* and copepoda), and live shrimp larvæ; they were all partially, none absolutely, successful. Cunningham usually fed the larvæ with particles obtained by crushing and pounding common shore-crabs, but he made special and careful trials of live food. Living minute animals caught in the sea in the tow-net were introduced, but none of the larvæ were seen to try to catch them. The fish larvæ and the larvæ of a shrimp were not attacked. But the fish larvæ and little shrimps, if killed before being put into the jar, were immediately seized. He concluded that the young lobsters are naturally carrion feeders, devourers of dead food, although inclined to cannibalism.

Mead found that the fry fed upon all sorts of minute organisms (copepods, diatoms, etc.), and readily ate some kinds of flesh if it was chopped into fine pieces and kept suspended in the water, where they came in contact with it. The best food was the soft parts of clams (*Mya arenaria*.) Chadwick fed the lobster fry "daily upon the finely-minced liver of the shore-crab (*Carcinus mænas*), and the edible crab (*Cancer pagurus*), and for a time they appeared to thrive on it, but at the time of the ecdyses or shell-castings many died, and comparatively few reached the 'lobsterling' [megalops] stage."

Appellöf reared the young lobster over the larval stages till the age, in one case, of seven months. A great mortality occurred owing to the inability of the larvæ to get rid of the integument when moulting. According to this zoologist, as soon as the third casting has passed, and it has reached the fourth stage [megalops], it swims, but soon goes to the bottom, and behaves like an adult. In the fifth stage the swimming power goes; they are then very sedentary.

Herrick describes a variety of food which he found in the stomachs of lobster larvæ, viz. (1) diatoms in abundance, chiefly *Navicula* and the long tangled ribbons of *Tabellaria*; (2) remains of crustacea, probably parts of young lobsters; (3) bacteria in large numbers; (4) cotton and linen fibres, and parts of algæ. "The food of the larval lobster must necessarily consist, for the most part, of minute pelagic organisms, such as copepods and crustacean larvæ. When watched in confinement they may now and then be seen giving chase to copepods, often without success. The young lobster, however, shows little discrimination in its food. It seems to snap up almost any moving object, living or dead, which it is able to seize and swallow." Herrick has stated that one difficulty arises in raising the young of the lobster in close quarters, from the fact that the young invariably preferred to feed on one another. The death-rate was, however, he considers, due in part to other causes. In this connection, an extract from the *Bulletin of the U.S. Fish Commission*, vol. xvii., 1897, p. 135, is interesting:—"During the spring and summer particular attention was paid to the food, habits, and growth of the young lobster, and much valuable information was obtained at Wood's Hole, where extensive experiments were conducted on the holding of fry during the larval stages. The experiments indicate that, under natural conditions, the young lobster is much less a cannibal than has been believed, eating his fellows only when natural food is not available."

LARVÆ—GENERAL DESCRIPTION.

The zoëæ are beautifully coloured in two predominant tints. On the dorsum, in the gastric region, the double luminous blue spot is conspicuous. Then generally all over they are pigmented blue on the dorsum of the thorax and abdomen, and yellow or red on the sides. Certain zoëæ, which to the naked eye have a slight bluish colouration, are seen, on examination with transmitted light, to have a great quantity of yellow pigment all over the body, the carapace, abdomen, and limbs, with the dorsum of the thorax and of the abdomen blue. Others are to the naked eye brilliantly coloured with dark red, which is seen by means of the microscope to be distributed similarly to the yellow in the zoëæ just described. There are different shades of yellow: some lighter, others darker. Occasionally the colouration shows to the naked eye a mixture of red with bluish purple. In 1904 most of the lobster zoëæ were red, but others were green, showing no red to the naked eye. Some were of a very pale green.

The young lobster, while it is still a zoëa, is, from its pelagic existence during a period of at least three weeks, exposed to many dangers. Its helpless condition, combined with its fairly large size, and conspicuous colouration, will, no doubt, result in its extensive destruction. Its life near the surface of the water will, however, give it, on the whole, probably a better chance of escape from small fishes than if it were swimming close to the bottom.

While it is a zoëa the lobster swims with its head bent downwards, and it attacks the food usually from above. It sees a white piece of the liver of the crab (*Cancer pagurus*) falling a good bit below it, and swims down in a spiral till it reaches it. It, however, chases copepods on a level with it, and also below it. When it is about to cast it seeks the bottom of the box. Some which were put into a glass tank kept boring away at the bottom in an endeavour to get down out of the strong light apparently.

The keen sight of the zoëa is a remarkable contrast to the purblind condition of the adult lobster.

In the megalops stage the young lobster for the first time crawls. It also swims, but now it swims forwards by means of its pleopods, with the two long chelæ held extended straight in front, in this way protecting its rostrum from any rude shock which collision with an object might produce. It also swims and floats in a manner similar to that known as "treading water," when it tries to grasp anything near the surface, and it turns round on its long axis after copepods at the surface of the water. It can also dart backwards by means of a rapid stroke of its telson, after the manner of the adult, but this in both stages usually follows surprise, and is adopted for escape. It sinks whenever it ceases using its swimmerets or telson. The megalops swims more than the later stages. It seems to support itself more easily in the water than they do. Its method of swimming is by means of its pleopods, that of a *Crangon* or *Palæmon*.

In this stage the antennæ are short, and their length seems to vary a little in different individuals. Certain megalopa have antennæ which reach just in front of the tip of the chela when it is stretched straight out alongside the rostrum. Others have much shorter antennæ. The setose exopodites are only present in some of the examples of this stage.

The megalops is the homologue of the sixth stage of *Crangon vulgaris*, in that it has practically the adult characters, save for its very short antennæ; It crawls about on the bottom of the box, and resists any wave

motion of the water which would tend to float it away. It clings with all its pereopods to the silk cloth of the bottom until the wave motion ceases, when it starts crawling again. Immediately the box is agitated, again it halts and holds on.

In its ability to notice particles of food, the megalops appears to be as keen-sighted as the zoëa. Mead contrasts the habits of the zoëa and megalops.

The next, that is the first young stage, swims about after copepods, and is to be seen swimming forward with the two chelæ extended together straight in front. The antennæ of this stage are longer than in the megalops, and the following stage has still longer antennæ.

The stages subsequent to the megalops are even more difficult to dislodge from the corner of the box. They cling tenaciously to the bottom (silk gauze) until the water is withdrawn and they are left stranded. Then they loose their hold to follow up the water. This fact probably accounts for these stages never being met with in the tow-net. They are really bottom forms, and in shallow water would require to be able to stick well to stones or in crevices to prevent their being washed away.

A young form will sometimes swim round the edge of the box with the off antenna stretched out in front and the near one thrown back along the body.

Appellôf remarks regarding the first young stage that they hide in dark corners or under stones. They are then very stationary. He draws attention to the great caution shown by the young lobster, and considers that, in consequence of that trait, a relatively large percentage of them should survive.

On the approach of winter the little lobsters in the Laboratory became very sluggish. In November and December 1902 they were rarely seen, except when the boxes were lifted. They stuck to the darkest corner of the box, and did not move about so much as they did earlier in the year. During these months there were hardly any copepods in the water supply, and this may have had something to do with their sluggishness. The increasing cold was, however, doubtless the main predisposing cause of their inactivity.

One of the most noticeable features that accompanies the transition from the zoëa to the megalops is the sudden change in the character of the animal. The zoëa swims about in an aimless way, except for the moments when it pursues a copepod. It paddles persistently, and when it strikes against the side of the box it jerks away quickly. It is not disturbed by noticing anything; all it appears to see is the little particles of food. It evidently sees short distances only. The main point is its indifference to possible danger; it does not attempt in any way to conceal itself. In the zoëa stage the lobster had no fear or premonition; in the megalops, it assumes with the adult garb the haunting fear of attack, which leads it to hide itself in some protecting crevice. It comes to rest in the darkest corner of the box, and while swimming about is always on the alert for a possible foe. For everything, food and protection, it has to be completely self-dependent. The desire to hide appeared with the necessity. The bottom life is, without doubt, a dangerous one, possibly more so than the pelagic existence it had just passed through. Its eye still enables it to pick up copepods; it is large, as in all the early stages of decopod crustacea. It no longer swims aimlessly about, but simply occasionally on a foraging expedition.

All the larvæ ate crab's liver, and hunt it by sight as it falls. And in the case of the megalops, when a little crabs' liver was introduced into the box, the lobster became very excited and rushed hither and thither,

following the scent dispersed by the current of water flowing through the box.

One little lobster took up its abode for a day or two in a *Purpura* shell which lay on the sand that covered the bottom of the aquarium, but when it attracted attention, it had excavated in the sand a hole below the shell, and in it it lay. The hole was deep to the front, and was a neat fit. The lobster pushed out a quantity of sand, two armsfull, in front of it, and removed larger grains of sand and a little piece of debris with its maxillipedes. When returning from a promenade round its prison it carefully tested its lair before it backed into it. It was alone in the aquarium. Now this lobster did not imitate an adult or any other young lobster in taking up its abode in the shell, or in digging a cave in the sand. When food was tumbled in it seemed to resent its approach. It appeared to be attracted by the scent at first, and then it put some fresh mussel that tumbled into its cavity out of the hole, while some mussel that was apparently old was left in. It was noticed that the mussel stuck to the pereopods.

Another little lobster, in its wandering about among the sand and mud, got its pereopods and maxillipedes covered with fine debris which, no doubt, consisted, in considerable part, of diatoms. It was observed to pick off the debris and put it into its mouth. Sometimes the mud in the aquarium was all punctuated as if it had been probed all over with the legs of the lobster.

THE LARVAL STAGES.

In the lobster the zoëa is a much more specialised organism than in certain of the other decapod crustacea, e.g. *Crangon* and *Carcinus*. One important respect in which the former differs from the two latter is in the possession of functional gills. The presence of the gills determines the form of the appendages concerned in the respiratory function, viz. the second maxilla, and the maxillipedes which are employed in securing a circulation of water through the branchial chamber. The gills and their arrangement being very nearly similar to the condition in the adult, it follows that the function of the appendages is that which they perform in the adult, and their form is therefore practically that of the adult. In *Crangon* and *Carcinus* the maxillipedes have no respiratory function to perform in the zoëa; they and the second maxilla are in form quite dissimilar from the adult condition. The adult form of these appendages are similar but not identical in the lobster and *Crangon*.

The stages which will now be described have not been determined by following a lobster in its successive moults. They have been discriminated from the general collection of larvæ which were developing in the hatchery. In the case of the higher stages, e.g. last zoëa stage, megalops, first and second young stages, the casts connecting adjacent stages were observed.

During the research it was found necessary to redissect this form which has already been treated by Sars and others, while the American species has been worked out by Smith and Herrick in elaborate detail, and profusion of drawings.

The drawing in the present case represents the condition found in the appendage examined. The opportunity did not occur to dissect several zoëæ of the same stage with a view to determine the variation in each limb, and from that to fix the normal condition. When a comparison has been instituted between the limbs of different zoëæ, variation in the hair arrangement, and in the nature of the hairs themselves, has been noted.

In the sketch the exact number and arrangement of the hairs, &c., has been attempted, except in the case of figs. 7 and 16, and the drawings of the protopodite joints. The exact number of setæ is not introduced on the exopodites, pleopods, uropods, or, in certain cases, on the telson. In the drawings of the complete larva the pereopods are represented semi-diagrammatically.

THE APPENDAGES OF THE FIRST ZOËA.

The appendages present in the first zoëa stage are—(1) the Eyes; (2) Antennules; (3) Antennæ; (4) Mandibles; (5) First Maxillæ; (6) Second Maxillæ; (7) First Maxillipedes; (8) Second Maxillipedes; (9) Third Maxillipedes; (10) First Pereiopods; (11) Second Pereiopods; (12) Third Pereiopods; (13) Fourth Pereiopods; (14) Fifth Pereiopods. It possesses all the cephalic and thoracic appendages which the adult has. The telson is triangular. The pleopods and uropods are not yet developed.

A detailed description is not necessary; in addition to the drawing of each appendage, short notes will be merely added here.

EYE, *o.*, fig. 4, pl. i.

The eye is large, and has a very short stalk.

ANTENNULE, *a.*, fig. 2, *ib.*

The antennule is crowned with three æsthetascs, one of which is specially large, and two hairs. A minute hair was found at the base of the æsthetascs on the antennule of one side, but not on that of the other side. A little short of the end of the antennule there is a little tubercle surmounted by a short plumose hair. In Sars' drawing of the appendage the plumose hair is shown larger than in the form here described. Herrick's drawing of the antennule of the first stage of the American lobster shows a more differentiated appendage.

ANTENNA, *A.*, figs. 1 and 24, *ib.*

The endopodite or flagellum (fig. 24) is two-jointed. It bears on its extremity four plumose setæ. The antenna represented by Herrick has a segmented or annulated endopodite.

The scale of one side had 23 setæ; that of the other side had 25 setæ.

MANDIBLE, *Mn.*, figs. 5, 6 and 18, *ib.*

The apparent joint in the mandible (fig. 5) above the origin of the palp seems to be simply the edge of its jointing with the cephalon.

The two hairs on the palp (fig. 18) have their distal halves finely serrated.

An enlarged drawing of the cutting edge of the mandible is shown in fig. 6.

FIRST MAXILLA, *1m.*, fig. 27, *ib.*

On the lower lobe the group of four hairs which have been, for convenience, represented as pointed downwards, should be directed upwards.

SECOND MAXILLA, 2*m.*, fig. 9, *ib.*

The second maxilla is really a maxillipede; it forms with the maxillipedes a series of appendages which, in addition to subserving a feeding function, also share the mechanical part of the respiratory process. This is performed by means of the epipodites.

The epipodite of the second maxilla is the lower half of the scaphognathite, while the exopodite is represented by the upper half.

The division of the second maxilla into joints is difficult to follow. My interpretation of the arrangement is as follows: (1) a basal joint; (2) immediately above that a bi-lobed joint; (1) and (2) form the protopodite. Above No. 2 there is a three-lobed joint, the endopodite. The scaphognathite, which seems to be divided at its middle into two joints, represents in its top half the exopodite, and in its lower half the epipodite.

There are 81 plumose setæ on the margin of the scaphognathite, and four small hairs on the surface.

On the elongated top lobe of the endopodite the long hairs are sparsely plumose; they are stiff spine-like hairs, with short, stiff cilia given off in pairs. The tips of the hairs are curved.

There are 20 hairs on the second lobe; they also have curved extremities. They are, with three sparsely ciliated exceptions, plain hairs; one hair only was distinctly serrated on its distal half.

The third lobe bears 13 hairs on the margin, and two on the under-surface. They resemble those on the second lobe; only a few are ciliated.

On the fourth lobe there are stout hairs sparsely furnished with stiff cilia on their proximal halves, and serrations on their distal halves.

The fifth lobe has long, stiff plumose bristles.

FIRST MAXILLIPEDE, 1*mp.*, figs. 7, 10, and 23, *ib.*

The first maxillipede (fig. 7) has a large first protopodite joint bearing a large epipodite. The upper lobe of the epipodite appears to be segmented off. The second protopodite joint is a flattened lobe bearing a large number of serrated spines on its margin (fig. 23).

The endopodite is two-jointed (fig. 10), and bears several long sparsely plumose bristles.

SECOND MAXILLIPEDE, 2*mp.*, figs. 29, 14, and 19.

From the first protopodite joint there arises two processes, united at their bases, one of which is a rudimentary gill, while the other is an epipodite (fig. 14). Both are hollow. An interesting condition was noticed in the gill, which may or may not be constant. The subject was not investigated. In the side of the gill there was a pore opening into a central cavity (fig. 14). The gill is not segmented. Between the wall of this central cavity and the outer wall there is a space which communicates with canals in the protopodite. The hollow of the epipodite communicates with a canal in the protopodite. In the drawing the canals are dotted; the basement tissue is striated.

The exopodite and endopodite arise from the second protopodite joint (figs. 29 and 19).

The exopodite, which is furnished with two terminal hairs and a little terminal protuberance, has a long basal joint and a long flagellum incompletely divided by two septa.

The endopodite consisted of four joints ; that is one less than what it has later, and which the first stage specimen dissected by Herrick had. The first long joint in the present case showed a trace of division into two.

The armature of the endopodite consists of serrated thorns resembling those on the same appendage in the VI. and VII. stages of *Crangon*. So far as was made out, they were, without exception, serrated. The serrations are minute, except in the large thorns. In fig. 29 the teeth are exaggerated.

THIRD MAXILLIPEDE, *3mp.*, figs. 8 and 16.

Two gills and an epipodite are attached to the first joint of the propodite. One of the gills is a podobranch, the other an arthrobranch (fig. 16). On the edge of the epipodite there are three hooks, of which the two larger are anterior. There is a second arthrobranch.

The exopodite had two terminal setæ and ten on each side. The annulations on the exopodite appear to be complete joints.

The endopodite has five joints. The spines are, almost without exception, serrated. Those on the under-surface (of the sketch) have two rows at least of large teeth ; the other spines have small serrations, of which there are two rows at least. The long terminal spine has very few serrations.

PEREIOPODS.

The pereiopods drawn are all of the right side.

The pereipod consists of seven joints, viz. (1) first protopodite joint—Coxopodite ; (2) second protopodite joint—Basipodite ; endopodite joints, viz. (3) Ischiopodite ; (4) Meropodite ; (5) Carpopodite ; (6) Propodite ; (7) Dactylopodite.

The setose exopodite arises from the basipodite.

FIRST PEREIOPOD, *1per.*, figs. 11, 20, and 28.

There are four gills connected with this limb—a podobranch, two arthrobranches, one pleurobranch, and an epipodite.

The endopodite has five joints, but the distal limit of the ischiopodite is shown by a line merely across the limb ; it is not a movable junction.

On the propodite the spines, almost without exception, are serrated ; those on the same side as the dactylopodite have prominent serrations, those on the opposite side very small serrations.

There were 22 or 24 setæ on the exopodite.

SECOND PEREIOPOD, *2per.*, figs. 22, 21, 12, and 15.

As in the preceding, appendage the first joint on the endopodite is marked by a line crossing what would otherwise be a first long joint of this branch ; giving five joints in all. The hand has serrated spines ; those on one side having larger serrations than those of the other side. There are three teeth on the inner edge of the dactylopodite.

There were 24 setæ on the exopodite.

Four gills and an epipodite are connected with this limb.

THIRD PEREIOPOD, *3per.*, figs. 13, 17, 25, and 26.

The endopodite is incompletely segmented ; it has four joints.

The spines on the claw of the propodite have large serrations.

The exopodite had 24 (26) setæ.

Attached to the appendage are four gills and an epipodite.

FOURTH PEREIOPOD, 5per., figs. 42, 52, and 45.

The endopodite shows five joints. On the propodite the spines have very large serrations on their distal halves, and smaller teeth on their proximal halves. On the other side the spines have small serrations. There are two kinds of serration on the long spine of the dactylopodite. At the base of this spine there is a tooth on the dactylopodite.

The exopodite had 24 (26) setæ.

Four gills and one epipodite are connected with this limb.

FIFTH PEREIOPOD, 5per., figs. 42, 52, and 45.

On the endopodite there is a little tooth at the base of the terminal spine.

The exopodite had 22 setæ.

One gill, a pleurobranch, is connected with the fifth pereopod.

BRANCHIÆ.

The number and the arrangement of the gills of the first stage zoëa are similar to the condition in the adult. Two of the gills, however, are here rudimentary. In fig. 49, pl. ii., the branchial cavity is shown. The gills are represented in the positions they occupy, but are shown much more slender than they actually would appear. They are packed close together. The division of the gills into podobranchiæ, arthrobranchiæ, and pleurobranchiæ is clearly shown in the case of the majority of the gills, but some there are which, from their position, might be regarded as pleurobranchs. In the adult, however, they are arthrobranchs, and very probably are arthrobranchs in the larva. They are the gills on the top row of the arthrobranchs in the following scheme. The Table exhibits the arrangement of the gills in the first zoëa stage (*vide* fig. 49). The gills are arranged in the branchial chamber in four rows. The highest row consists of four pleurobranchs belonging to the second to fourth pereiopods. The next row consists of five arthrobranchs which are connected with the third maxillipede and first four pereiopods. The third row comprises another set of five arthrobranchs attached to the same appendages. The fourth row includes six podobranchs, borne by the second and third maxillipedes and the first four pereiopods. The first and last of the series are rudimentary gills. Each of the above-mentioned appendages, with the exception of the fifth pereiopod, has an epipodite. On the coxopodite of the last pereiopod there is a small process which may represent the epipodite.

Herrick says that in the American lobster there is no rudimentary gill attached to the second maxillipede.

In Fig. 49 the following letters are used:—*pl.-br.*, Pleurobranch; *ar.-br.*, Arthrobranch; *pd.-br.*, Podobranch.

Branchiae of First Zoëa Stage.

1st Row	-	Pl.	Pl.	Pl.	Pl.	..	..	..
2nd	„	-	..	Ar.	Ar.	Ar.	Ar.*	..
3rd	„	-	..	Ar.	Ar.	Ar.	Ar.	..
4th	„	-	..	<i>Pd.</i>	<i>Pd.</i>	<i>Pd.</i>	<i>Pd.</i>	<i>Pd.</i>
„	„	-	..	Ep.	Ep.	Ep.	Ep.	Ep.
Appendage.		5 per.	4 per.	3 per.	2 per.	1 per.	3 mp.	2 mp.

ABDOMEN.

On the dorsum of the abdomen there are three single spines and a pair of hooks. The spines arise from the third, fourth, and fifth abdominal segments, and the pair of hooks are situated on the hind border of the sixth segment. In the larva of the American lobster there is a small hook on the second segment also.

There are four pairs of rudiments of pleopods; they are paired swellings projecting below the ventral line. Each is widely separated from the other pleopod of the pair. The integument is apparently perforated for the outward growth of the appendage, in a manner similar to the bud of a new limb. Inside, a fold can be seen.

In each segment there is a pair of nerve ganglia. In the examination of the first stage of *Carcinus* the ganglia are noticed, but were not recognised.† There is a little tooth on the side near the anus. On the hind border of the telson there are 16 (17) little setæ on either side of the median spine. In the dorsal view of the abdomen and telson the exact number of setæ is not shown on the hind border of the telson.

FOOD OF THE ZOËA.

The stomach of one zoëa contained the integument of a copepod.

SUBSEQUENT STAGES.

As mentioned above, there has been some difference in opinion regarding the number of stages into which the zoëa period is normally divided. In the European lobster Sars distinguished three stages; Saville Kent made out four distinct stages; Chadwick has described three stages. Herrick, for the American lobster, discriminated three zoëa stages only.

The difficulty arises from the fact that during the zoëa period the different developing appendages do not proceed *pari passu*; and while, no doubt, there is normally a correlation between the organs which results in a certain stage of development in the one being usually associated with another certain stage in the second appendage, still the variation

* The arthrobranch in the second row, connected with the third maxillipede, is hidden by the adjacent arthrobranch of the first pereopod.

† Vide Williamson. The Larval and Early Young Stages of the Shore-Crab (*Carcinus mænas*), p. 157.

is comparatively very large. How is the number of zoëa stages to be fixed? The most direct method is to watch a zoëa in its development from hatching till it reaches the megalops stage, when it changes its mode of life and assumes the form of the adult. In the zoëa period every moult ushers in a new stage. As will be shown later, however, the megalops is not a fixed condition; a large amount of variation occurs in its structure. The development of a single example would not be sufficient; a number would be necessary. In the zoëæ of *Crangon* and *Carcinus* variation was noticed, especially in the size of larvæ of the same developmental stage. These zoëæ are of very small size, whereas the lobster larva is large. The variation, then, in the latter is of much greater absolute size. The variation in size and in the development of the appendages together result in a multiplication of forms. Causes which are at present unknown—they may be food, temperature, salinity of the sea-water, &c.—stimulate development in certain or all the characters in some larvæ, while apparently similar conditions of environment result in delayed development in other specimens. The method adopted in the present case has been to group the zoëæ into as many groups as they naturally fall into. Of these there are three. But the extent of variation is sufficiently large to bring into prominence three other distinct forms. In the first group of zoëæ there are two dimorphic forms, and it might be inferred from that fact that we had simply to deal with two parallel series, but that does not appear to be the case. One case at least occurred where a larva belonging to one series passed by a moult apparently into the other series.

The zoëa stages are very readily distinguished by the stage of development of the pleopods. During the zoea period the pleopods develop and become functional for the first time in the megalops. This occurred, without observed exception, in the case of *Crangon* and *Carcinus*.

In *Homarus* the first zoea has the rudiments of the pleopods; they do not project from the abdomen; they are merely paired swellings on the posterior part of the under-surface of the abdominal segment. In Stage II. the pleopods project as unjointed bifid processes. In Stage III. they are large two-bladed appendages.

In the first zoëa the cornea of the eye is attached to the carapace; the eye is sessile. In the second and third stages it is quite free from the carapace; the eye is distinctly stalked.

The telson in the first zoëa is triangular, its hind margin fringed with plumose setæ. No uropods are present. The uropods appear in Stage III.

In each stage there is a marked variation in size, and the large individuals usually show considerable divergence in structure from the small specimens of the same stage, in respect to the developing appendages.

In Stage I. one or two large specimens, Ia. (fig. 67), but not all, showed a telson differently shaped from that of the smaller. But between these two, some larvæ showed intermediate forms of the telson. Then a difference in the size of the ventral swellings (pleopods) on the abdomen was noticed, but the more prominent swellings were not confined to zoëæ having the second form of telson.

In Stage II. (fig. 68) the outstanding difference between the larvæ was that of size; a dimorphic form was not noticed here.

In Stage III. (fig. 69) difference in the size and structure of the pleopods is common. The dimorphic form of the third zoëa (fig. 71, pl. iv.) is one which, in structure, is intermediate between Stage III. and the megalops.

None of these dimorphic forms have, so far as I am aware, been previously recorded and described. It is possible that their origin may,

in some measure, be due to the environment; the conditions, favourable and unfavourable, of their life in the Laboratory may have resulted in stimulating these irregular forms. The lobsters were under the influence of this environment for a month or so while in the egg, and afterwards during the whole of their free existence. The parent lobsters were from two widely separated localities, viz. the East and West Coasts of Scotland. The young forms were mixed together in the hatchery. The different origins of the parents might be accompanied by variation in development of the larvæ.

It is convenient to discuss the stages in the order of their sequence.

STAGE I.—Saville Kent breaks up this stage into two stages, which he separated by two characters:—

- (1) Difference in size.
- (2) Difference in the number of dorsal spines on the carapace.

Difference in size is not a character of value; and as regards the second, I have not been able to discover this difference.

A very marked difference was found, however, between certain of the first zoëæ, in the shape of the hind border of the telson. In the majority the hind margin makes with the hooks at the angles of the base a return curve of comparatively small radius (fig. 30). In some of the larger specimens Ia. (fig. 67) the telson is broader, the curve of the hind margin is a much shallower one, the lateral hooks being directed posteriorly instead of inwards (fig. 46). The setæ on the hind border are very short, while in the first described case the setæ were fully half the length of the median spine. Now, in *Crangon vulgaris*,* the second stage differs from the first in having a telson of slightly different shape, accompanied by a greater number of spines on the hind border. There is also a difference in size. This fact would suggest the possibility of the two forms in Stage I. being independent stages, but the length of the setæ was found to be variable, and cases occurred where it was impossible to say, from the length of the setæ, to which form the individual belonged. I have come to the conclusion that there is not sufficient differentiation to warrant its elevation to a separate stage.

The second zoea (fig. 68, pl. iv.) is the first stage in which the pleopods project. They are unjointed bifid processes. They issue, by foramina in the integument, from the posterior part of the under-surface of the 2nd, 3rd, 4th, and 5th abdominal joints. The telson (fig. 48, pl. ii.) has 16 little setæ on either side of the median spine. On the outside of the setæ there is a little spine at the base of the lateral hook. The uropods are not yet free, but may be traced through the integument of the telson. Two zoea of this stage measured 10 and 12mm. respectively—a very conspicuous difference in bulk.

The third zoea shows a certain amount of variation, and between the third zoea and the megalops, and in the megalops, variation is well marked. The dimorphism was noticed in respect to two characters especially, viz. those which are in process of development in the zoea period, e.g. the antennæ and the pleopods.

The third zoea (fig. 69, pl. iv.) is characterised by the possession of uropods. The telson, which is square, is toothed along its hind border (fig. 35, pl. ii.). There were 18 teeth on either side of the median spine in the specimen examined. On one side there was a little setose hair. Two or three short plain hairs were found on the dorsal surface of the margin. The pleopods (fig. 37) are larger; each consists of a thick stem, bearing two paddle-shaped processes. They are constricted off from the stem, but not by movable joints. The paddles are set across the abdomen,

* Vide Williamson.

and are fringed on both edges of their distal halves with short, stout plain hairs. The exopodite overlaps the endopodite on the anterior side of the latter. In the third pair of pleopods of one larva there were 21 hairs on the exopodite, viz. 13 on the outer side, 2 terminal, and 6 on the inner side, *i.e.* next the endopodite. The endopodite was somewhat smaller than the exopodite, and bore 19 hairs, viz. 3 terminal and 8 on each side. The endopodite extends as a continuation of the stem of the appendage. There is a variation in this stage which is common; it is the case wherein the pleopod is furnished with rather longer fringing hairs, a proportion, larger or smaller, of which are sparsely plumose. The pleopods apparently function to a slight extent in this stage.

The two forms observed of the third stage then are:—*IIIa*, zoëæ having pleopods fringed with *short plain* hairs; *IIIb*, zoëæ having pleopods fringed with *rather longer* hairs, which are in part *sparsely plumose* (fig. 36, pl. ii.). It is possible that *IIIb* is the more common. This was the structure of the pleopod in the III. zoea stage described by Smith.

The most striking secondary form is one which partakes of the characters of both zoëæ and megalops. It will probably be more convenient, then, to define the normal or average megalops before proceeding to discuss the intermediate variation.

The zoëæ has certain prominent characters; these are the dorsal hooks on the abdomen, the purely maxillipede form of the pereopods, the swimming exopodites of the thoracic appendages, and the stumpy antennæ, which do not function as feelers. The pleopods in the zoëæ are not fringed with long plumose setæ.

The megalops stage is marked by the antennæ being long, minutely jointed, and used as feelers. The pereopods function for walking; the exopodites are greatly reduced. The pleopods are furnished with long, densely plumose setæ, and have become powerful swimming organs. The dorsal hooks on the abdomen are absent.

The intermediate stage, which is, for convenience, labelled thus "IV." in the plates, was quite common among the larvæ that were reared. Fig. 71, pl. iv., represents the most common condition of this form; for it also varies. The antennule and the antenna are still not fully developed; the former is single, and bears at its extremity a bunch of hairs. The antenna is longer than it is in Stage III.; it shows some segmentation, and coming joints are indicated externally by the presence of little hairs; it is not a functional feeler. In other respects this form is a zoëæ. The spine and hook armature of the abdomen is that of the zoëæ. The pereopods and their exopodites are in the zoëæ condition. Drawings of the first pereopod are given in figs. 43, 44, and 38, pl. ii. The part of the second protopodite joint which bears the exopodite is now segmented. The epipodite is also segmented off from the first protopodite joint (figs. 44 and 38). The protopodite of the second pereopod is represented in fig. 39, pl. ii. The endopodite has five joints—a chelate tip.

It resembles a megalops in its pleopods, telson, and the hand of the first pereopod. The pleopods are large, and fringed with long plumose setæ. On the third pleopod (fig. 51, pl. ii.) there are on the exopodite 33 setæ, and on the endopodite 30 setæ. The exopodite overlaps the endopodite on the anterior surface. The hand of the first pereopod was long, resembling that of a megalops rather than that of the zoëæ (fig. 43, pl. ii.).

The Stage "IV." varies to the extent of having its pleopods furnished with comparatively short hairs, some of which at least are sparsely plumose. This is the condition found in the modification of the third stage zoëæ, labelled *IIIb*. The largest specimens are usually furnished

with the pleopods of the megalops. The telson of the "IV." stage, which was drawn, had no median spine on the hind border; in this stage a median spine is usually present.

Stage "IV." attracts attention from the fact that in general shape and large size it resembles a megalops. The use of the pleopods for swimming give it the characteristic megalops appearance. It swims with the chelæ stretched straight out in front of it. It may be regarded either as a backward megalops, or as a precociously developed zoëa. From the point of view of the former, the antennæ, which are so prominently employed by the megalops, have developed more slowly than the pleopods. We have, in fact, a megalops which has carried over certain zoëa characters, viz. antennules, antennæ, the purely maxilliped form of the pereopods, and the abdominal hooks. There are other cases in which minor zoëa characters are carried over and exhibited in the megalops; they will be referred to later. If the second view is adopted, we are led to the interesting conclusion that an organ may by precocious development become functional in a stage which is normally without it.

Might not an unusually rapid growth of the zoëa in size necessitate the earlier provision of swimming organs to assist the exopodites which were sufficient in the smaller stages? Or might a lower salinity react by stimulating the development of greater swimming power? The zoëa has attained to the body of a megalops, and the result is the provision of the means of moving it about.

Boas describes considerable difference in structure between the larvæ and adults of the fresh-water and sea-water forms of *Palaemonetes varians*. The larva of the former is larger than that of the latter.

The megalops stage is illustrated by several figures. Fig. 72, pl. iv., shows the lobster in this stage. The pereopods are represented by figs. 60, 61, 62, and 58, pl. iii., while the abdomen and telson are shown in figs. 57 and 63, pl. iii.

The exopodites of the pereopods are present, and setose, though very much reduced; but variations in the exopodites are common. In the stage following the megalops, viz. the first young stage, the exopodites are reduced to little processes (*vide* figs. 59, 65, 70, pl. iv.).

While dissecting a megalops the first pereopods broke off at the junction between the basipodite and the ischiopodite. These joints, so far as could be made out, were fixed, as they are in the adult. This is the fracture plane of Fredericq. The broken limb showed a clean but not very regular break (fig. 58, pl. iii.). The muscles in the ischiopodite run right down and terminate at the proximal end of that segment. The muscles of the exopodite may have something to do in effecting the fracture.

The pleopods are similar to those of Stage "IV." (fig. 51, pl. ii.). The setæ have long, stiff cila, and resemble generally the setæ on the pleopod of the megalops of *Crangon vulgaris*.

The telson of the megalops had a median spine on the hind border. This spine is usually absent; it is a zoëa character.

The chela resembles that of the first young stage (fig. 65), but the tubercles on the meropodite are a little less prominent.

The first young stage resembles much the megalops (*vide* fig. 70, pl. iv.), but is usually larger. The exopodites of the thoracic limbs are small processes, no longer setose. The antennæ are longer than in the megalops. The pleopods are similar to those of the megalops. The rostrum is bifurcate. On the whole, the lobster in the first young stage resembles much in its habits the lobster in the megalops stage. It does not appear to swim quite so much.

The first pereopod of this stage is figured in figs. 65 and 59, pl. iii

The little hairs on the propodite and dactylopodite are probably sensory. Fig. 64, *ib.*, gives a dorsal view of the telson.

VARIATION OF THE MEGALOPS.

A typical megalops may be described as follows. It walks about by means of the pereopods, which are now of the adult form, and it swims by means of its large pleopods. The exopodites of the thoracic appendages are present, but in varied structure. They may be setose, or much reduced, and without setæ. The antennæ now project as far in front as the chelæ can reach, and are used, as in the adult, as feelers. The rostrum is bifurcate at the tip. The eyes, like those of the zoëa, are very large.

The megalops varies in several ways—the following were specially noted:—

(1) It as often as not has one or more of the dorsal abdominal hooks of the zoëa persisting.

(2) It may have the median spine on the hind border of the telson—a zoëa character.

(3) The exopodites may vary very much. Some or all of them may be setose, or they may be reduced to little processes, as in the first young stage. The exopodite of the first pereopod does not usually have any setæ.

The following Table gives an analysis of 12 megalopa with respect to three characters. The sign + signifies the presence, and - the absence, of the character; if no sign is entered the character had not been noted.

	Dorsal Hooks on Abdomen.	Median Spine on Telson.	Exopodites— some Setose.	Exopodites reduced to small pro- cesses.
4 Megalopa,	+		+	
1 Megalops,	+			+
5 Megalopa,	—		+	
1 Megalops,			+	
1 Megalops,		+		

FORMS RESULTING FROM THE CASTING OF III. AND "IV." ZOËÆ.

Particulars were kept of various casts of the III. zoëa and of the "IV." stage. The resulting forms were observed, and are entered in the following Table:—

[TABLE.

Stage.	Cast into	Special Characters of Resulting Form.
IIIa.	"IV."	Pleopods and Telson of Megalops.
IIIa.	"IV."	
IIIa.	Megalops.	Short Antennæ.
IIIb.	"IV."	Pleopods of Megalops.
IIIb.	Megalops.	
IIIb.	"	
IIIb.	"	
IIIb.	"	
"IV."	"	In some respects, <i>e.g.</i> Exopodites of Pereiopods, resembled First Young Stage.
"IV."	"	" " "

GROWTH OF THE YOUNG LOBSTER.

The larval stages of the American lobster have been fully treated by Herrick, who followed its life-history from the time of hatching to the tenth stage, when the animal is over one inch long and about three months old. He says that the young lobster ceases to swim in the sixth stage.

In the Laboratory here the young lobsters have been kept for various intervals up to ten months. Rearing experiments were carried on in the summer of 1902 and the summer of 1904. In the case of the lobsters which were kept for several months, it was not possible to tell in what month they were hatched, but as the greatest number of the fry hatched out in August, the middle of that month has been taken as the date from which to calculate the age of the young lobsters. The growth in the cases here cited is possibly abnormally slow.

A. 1902 Brood—Hatched in August 1902.

1. September 28–30th 1902.—Megalopa issued from three specimens of the large "IV" zoëa.
- „ October 30th.—One megalops cast.
- „ November 6th 1902.—Another megalops cast.
2. October 1st.—A zoëa cast into a zoëa of "IV" stage.
- „ November 7th.—The "IV" zoëa was partly cast to megalops.
- „ December 5th.—The megalops was dead; 1.6cm.
3. October 2nd.—A zoëa cast; a megalops issued.
4. November 7th.—A megalops cast.
5. November 21st.—A first young stage lobster cast.
- „ December 4th.—The soft lobster, second young stage, was found dead; 1.4cm.
6. December 13th.—A lobster of the second young stage died; 1.7cm.
7. January 15th, 1903.—A first young stage lobster died; 1.7cm.
8. „ 17th.—A first young stage lobster died; 1.8cm.
9. „ 27th.—A second young stage lobster died; 1.7cm.
10. May 29th.—A second young stage lobster cast.
- „ June 11th.—The soft lobster, third young stage, died 1.8cm
11. May 31st.—A second young stage lobster cast.
- „ „ .—The soft lobster, third young stage, died; 2.2cm.

B. 1904 Brood—Hatched in August 1904.

12. October 27th 1904.—Young lobster, first young stage, cast.
- „ November 3rd.—The soft lobster, second young stage, died ; 1·cm.
13. 31st October.—Young lobster cast.
- „ November 3rd.—Soft lobster died ; 2·5cm.
14. June 4th 1905.—One young lobster, the sole remaining, measuring 1·9cm, cast.
- „ „ 14th.—The young lobster died ; 2·1cm.

Casting of zoæ occurred as late as October and November and of megalops and later stages in October, November, May, and June.

LENGTH OF DIFFERENT STAGES.

The last zoæa stage lasted, in the case of No. 2, from October 1st to November 7th, a period of five weeks.

The megalops stage lasted, in the case of two examples in No. 1, from September 30th to October 30th and November 6th, *i.e.* four and five weeks respectively.

Appellôf records that two lobsters in the same jar differed from one another by a month in arriving at the sixth stage. Casting took place also in winter.

Sizes of the young lobsters which died, and their approximate ages (from hatching) at death :—

Stage.*	Age.	Length in Cms.	Number in preceding List.
M	2 months	1·6 : 1·7	..
M	2½ „	1·6	2
+2	2½ „	1·7	12
..	2½ „	2·5	13
+2	3½ „	1·4	5
+2	4 „	1·7	6
+1	5 „	1·7	7
+1	5 „	1·8	8
+2	5 „	1·7	9
+3	9 „	2·2	11
..	10 „	2·1	14
+3	10 „	1·8	10

* The following contractions are used in this column :—“M,” Megalops ; “+1,” first young stage, *i.e.* stage immediately following Megalops ; “+2,” second young stage, &c.

Additional measurements of lobsters of different stages:—

Date.	Stage.	Measurements. Mm.
Sept. and Oct. 1902.	"IV" Zoëa.	1·5 : 1·5 : 1·6 : 1·6.
"	M.	1·5 : 1·5 : 1·5 : 1·5 : 1·6 : 1·6.
Sept. 1902.	+1	1·55 : 1·55 : 1·6 : 1·65 : 1·7 : 1·7.

DEATH OF THE YOUNG LOBSTERS, FIRST YOUNG STAGE AND LATER.

The majority of the young lobsters reared at the Laboratory have died shortly after casting. As a rule, the death took place gradually, as if a disease had seized them immediately on casting. The lobster became at once sluggish, moved about with difficulty, and simply ebbed away.

October 23rd (No. 3).—One of the young lobsters cast, but became weak immediately after, and was hardly able to move a limb. It was removed to a larger vessel with a good supply of water, and it seemed to be reviving on the 28th. On October 31st it was livelier; it could move its pleopods, but seemed to be paralysed in the thorax; a faint movement of the antennules was noticed. It had a large swelling on its left side at the hind part of the carapace. It was dead on November 3rd.

On October 31st (No. 5) a lobster that had not cast recently was seen to be almost dead; there was just a little movement detected in the last pleopod. On November 3rd it was dead and covered with a fungoid growth.

On November 3rd (No. 6) a lobster which was half-cast was found as if dead. No movement was noticed. The lobster was torn asunder, and it was then seen that life still remained, as vermiform movements of the organs were detected. A puff of white fluid material was squeezed from the anterior half of the body, and examined by means of the microscope. It was seen to consist of great numbers of infusors of various kinds, the majority being very small and roundish in shape; others were long, pear-shaped. Some were progressing with an eel-like motion. Sporospheres consisting of a mass of minute infusors were made out. The water in which the lobster was had no infusors in it when a drop was examined.

The death of the young lobsters is, without doubt, due to the rapid development in them of these infusor parasites. It is possible that during the casting process the infusors may gain admittance to the body, and their rapid multiplication there results in the death of the host in a few days.

One lobster, the largest reared, measuring 1 inch (2·5cm.) in length, reached that size by a cast on October 31st 1904. On November 3rd it appeared to be dead. On examination a little movement was detected in its limbs. It was removed to a large jar, but did not recover.

BERRIED LOBSTERS OF SUMMER 1902.

The parent lobsters from which the supply of larvæ was obtained in 1902 were kept alive in the Laboratory after the hatching finished. Two survived till the spring of 1905. The history of these and of other lobsters which were kept in confinement will now be detailed.

One lobster was found clean hatched on August 2nd 1902, and by September 10th all but one had hatched out their eggs. The exception was a lobster upon which a quantity of dead eggs remained attached to the swimmerets. On September 22nd one lobster cast its shell; when examined on October 14th the shell of this individual was not hardening quickly. None of the others cast, and none spawned. If spawning actually occurred none of the eggs became attached to the adult. The lobsters were ten in number on January 16th 1903. None, so far as could be made out, had spawned; one had still a quantity of empty egg-capsules, visible to the naked eye, attached to the swimmerets. The soft lobster died on June 6th 1903.

On July 6th 1903 eight of the 1902 hatchers survived. During that month six cast their shells; one cast in August, and the eighth died in July. Of the six which cast in July, three died in the process of casting.

The four soft lobsters had not spawned in October, in which month a male lobster was introduced into the tank with them. On January 13th, 1904 the male lobster was still with them; none had become berried.

One of the females was found cast on July 19th 1904, and it died the following day. A second cast on July 29th. The third was found dead on August 30th 1904. There were left at that date two lobsters; one of these had cast its shell in 1903, and also in 1904; the other had cast in 1903. The male lobster remained with the latter. Both females were still unberried on 21st October. Neither had spawned by January 12th 1905. The lobster that cast in 1904 was found dead on February 16th 1905, and the remaining specimen had died by April 6th 1905.

During the two years and nine months the majority cast their shells, but none became berried.

A FEMALE THAT SPAWNED.

A marketable* female lobster arrived from Dunbar in December 1902. It had a clean shell, and did not appear to have been berried. It cast its shell on September 2nd 1903. When examined on the 12th October following it measured $10\frac{5}{8}$ inches in length. It was not berried on January 13th 1904, but on July 14th it was found to have a small quantity of eggs attached to the swimmerets. The eggs were early, just spawned. No male lobster was present when the eggs were spawned. These appeared to be healthy, dark green in colour, with a clear dotted area to one side. The lobster had lost all its eggs but two by October 21st 1904, and when examined on November 19th of the same year it was clean. On the subsequent examinations, viz. January 12th, May 6th, and June 19th 1905, the lobster was still clean. It moulted on July 2nd, 1905, and was killed then. This cast has not been entered in the table on p. 90.

BERRIED LOBSTERS OF 1903.

Some berried lobsters, eight in number, were obtained from Dunbar in September 1903. Two had well-developed eggs, and the eggs hatched soon after arrival. By September 24th two more had hatched their eggs; a few eggs remained attached to one lobster. The four others had black

* A lobster is marketable when it is eight inches, and over in total length of body.

eggs, which appear to have been freshly extruded. They were not retained at the Laboratory; the clean-hatched lobsters were preserved alive. During the winter that followed none, so far as was noticed, spawned, and on January 23rd 1904, of the three that remained, none was berried. One lobster cast on July 9th 1904. The cast shell was clean; the antennæ which had been most exposed to the light had some algæ growing on them. It died on July 14th. The second lobster cast on July 13th, and the third on July 25th.

By October 21st 1904 only one survived, and it was not berried. It was examined again on November 19th 1904, January 12th 1905, May and June 19th 1905, and on each date found to be unberried.

BERRIED LOBSTERS OF 1904.

A stock of berried lobsters, 20 in number, were obtained from Girvan and Dunbar in June and July 1904. All but five hatched their eggs by the end of August. These were still berried on October 12th 1904. Of the others, one cast in August, one cast in September, four more had cast by October 12th 1904, a seventh cast on October 29th 1904, and the eighth was found cast on November 1st 1904. Of the fifteen which hatched their eggs, eight cast their shells by November 1st. The remainder, seven in number, were examined on December 15th 1904, January 12th 1905, May 8th and June 19th 1905. None had become berried. At the examination in May one had died.

Six of the soft lobsters had died by November 16th 1904; none of them had spawned. On January 12th two were alive, but they had succumbed by May 6th 1905.

When the berried lobsters were examined on October 12th 1904 the external eggs showed, under the microscope, a considerable pink area at one pole, wherein were to be made out the pigmented eyes and the rudiments of the limbs. The great mass of the egg consists of black yolk. The lobsters had probably spawned their eggs just before they were captured in July.

On January 12th 1905 the reddish or amber-coloured area had increased a little; it extended well round the black yolk. The eye of the embryo has a prominent black retina; the limbs are distinct.

When examined on May 6th 1905 the eggs showed a further increase in the red area; it extended almost completely round the yolk, but was still narrow in most of the eggs. At this date four lobsters remained; of these, one had got rid of its eggs. Two were clean on June 19th 1905. The eggs of the two others were far advanced.

PROPORTION OF BERRIED HENS IN THE CATCH OF LOBSTERS.

As to the proportional numbers of berried to unberried females captured by the fishermen, Herrick's observations showed that in April and May the largest percentage of berried females were captured in Wood's Hole Harbour. In these months the berried females formed 40 and 36 per cent. respectively of the total number of female lobsters taken.

Ehrenbaum found that at Heligoland the berried hens were taken in largest numbers in July, August, and September, during which months, in the period covered, the percentages were 35, 46, and 44 respectively of the total females.

Cunningham's statistics of the lobsters caught in the Cornwall district show that in April, May, June, and July the berried females form a considerable proportion of the total catch. In the three years 1895-

1897 the proportion of berried hens during the months March to July, amounted in some cases to 50 per cent. of the females captured. For the four months April to July, at Cadgwith in 1899, out of a total of 443 females, 108 were berried hens.

Meek has published statistics of the catch of lobsters and crabs during the past six years, 1899–1904, both inclusive. The monthly totals at Seahouses and Beadnell are given for each year. The lobsters are classified as hard, small, and berried. The largest number of berried females were, as in Cornwall, captured in April, May, June, and July. For the six years the berried hens made up on the average in these months 28, 34, 32·7, and 22·8 per cent. respectively of the females captured at Seahouses.

THE CASTING OF THE LOBSTER.

The Male Lobster.

A male lobster obtained in October 1903 was kept in a tank along with four soft female lobsters. On April 14th 1904 it was found to have cast, and on July 14th following it was already hard. It was noticed that it was an eager feeder. When examined on November 19th it appeared to be soft to the touch, and on November 21st it had again moulted; that was after an interval of seven months only from the previous cast. It was killed by the female lobster that was with it in the tank. It had bled to death; the injuries were not very extensive. It measured at its death $11\frac{1}{2}$ inches in total length.

Two male lobsters which were kept in confinement by Brook cast twice in each of two successive years. One, measuring $7\frac{1}{4}$ inches in length, cast in (1) May and again in (2) September 1883, and also in (3) May and (4) October 1884. The size after each cast was (1) $7\frac{1}{8}$ inches, (2) $8\frac{1}{8}$ inches, (3) $9\frac{3}{8}$ inches, (4) $9\frac{3}{4}$ inches. The second male lobster measured $6\frac{1}{8}$ inches. It cast in (1) July and (2) December 1883, and in (3) June and (4) November 1884. The size after each cast was (1) $7\frac{3}{8}$ inches, (2) 8 inches, (3) $8\frac{1}{8}$ inches, (4) $9\frac{3}{8}$ inches.

The Casting Periods.

The lobsters which moulted at the Laboratory did so in the following months:—April, July, August, September, October, and November. All these observations refer to adult lobsters 8 inches and over in length, which were nearly all females. Most of the females were lobsters which were berried when they arrived at the Laboratory. In the following Table they are indicated by the letters e.h. (eggs hatched).

The Table which follows shows the date on which the lobster cast, its length before casting, and sex. The interval of time that has elapsed since the eggs were hatched is given in one column, and the interval between two successive casts is shown in the three cases where it occurred.

The numbers indicate separate moults: the same lobster appears twice in three cases.

No.	Date.	Size before Casting.	Sex.	Interval between Hatching the Eggs and Casting.	Interval from Previous Cast.	Period of Captivity before Casting.	
		Inches.					
1	April 14, 1904.	...	♂	...	...	...
2	July 6, 1903.	$12\frac{7}{8}$	♀ e.h.	1 YEAR.	...	...
3	" 15, "	$12\frac{1}{2}$	♀ e.h.	1 "	...	...
4	" 20, "	11	♀ e.h.	1 "	...	...
5	" 21, "	$10\frac{5}{8}$	♀ e.h.	1 "	...	...
6	" 22, "	...	♀ e.h.	1 "	...	...
7	" 29, "	11	♀ e.h.	1 "	...	...
8	" 1904.	$11\frac{1}{2}$	♀ e.h.	1 "	...	...
9	" "	$11\frac{5}{8}$	♀ e.h.	1 "	...	...
10	" "	12	♀ e.h.	1 "	...	...
11	" "	$12\frac{3}{4}$	♀ e.h.	2 YEARS.	1 YEAR.	...	
12	" "	11	♀ e.h.	2 "	1 "	...	
13	July 28, 1902.*	...	♂	...	...	...
14	August, 1903.	11	♀ e.h.	1 YEAR.	...	...
15	" 1904.	...	♀ e.h.	1 month.	...	...
16	Sept., 1902.	$9\frac{1}{2}$	♀ e.h.	1 "	...	...
17	" 1904.	...	♀ e.h.	1 "	...	...
18	" "	...	♀ e.h.	1 "	...	...
19	" 2, 1903.	11	♀ e.h.	1 YEAR + 1 month	...	...
20	" 2, "	$[10\frac{1}{8}]^{\dagger}$	♀	...	...	9 months.	Was berried in July 1904.
21	Oct., 1903.	$11\frac{3}{4}$	♀	...	...	1 YEAR.	
22	" 1904.	...	♀ e.h.	2 months.	...	...
23	" "	...	♀ e.h.	2 "	...	...
24	" 12, 1904.	$11\frac{1}{4}$	♀ e.h.	2 "	...	...
25	" 29, "	$10\frac{7}{8}$	♀ e.h.	2 "	...	...
26	Nov. 1, "	11	♀ e.h.	3 "	...	...
27	" 21, "	...	♂	...	7 months.	...	

* Cast at Dunbar.

† Size of soft lobster.

The total number of casts recorded above is 27. They occurred in the months of April, July, August, September, October, and November. A summary of the casts is here introduced.

TABLE SHOWING THE NUMBER OF CASTS IN EACH MONTH.

	Sex.	April.	May.	June.	July.	August.	September.	October.	November.
Number of Casts of each Sex	♂	1	..	..	1	..	..	..	1
	♀	11	2	5	5	1
Total for month	..	1	..	..	12	2	5	5	2

So far as the class of female lobsters here dealt with is concerned, there are two fairly distinct casting seasons. One, which is at its maximum in July, claimed those females which were not berried during the previous winter,* while the second is an autumn casting season, the principal months being apparently September and October. In the autumn season those females that were berried during the previous winter and spring cast;* that is to say if they cast at all during that year. The two seasons overlap, however. On September 2nd one of the first class of lobsters cast, and the list includes, for August, one of each class.

The two cases in which the lobsters cast two years in succession, viz. Nos. 11 and 12, are interesting, from the fact that the view has been held that the adult lobster would not cast two years in succession. Appellôf maintains that view. The frequent castings of Brook's specimens and of the two males recorded above are important as indicating a possible divergence in rate of growth from the female.

It certainly seems that in captivity the casting process becomes more frequent than in the case of the lobster in the sea. The inactive existence of the creatures, and the absence of any search or exertion on their part in the quest for food, may have predisposed them to vegetate in place of reproducing. The food supplied was not excessive in quantity; it consisted of shelled mussels (*Mytilus edulis*) and fish.

The Increase in Size on Casting.

One fact has been noticeable in connection with the moulting that occurred at the Laboratory, and that is the small increase in size that has followed the casts.

It is sometimes difficult to accurately measure the moulted shell, owing to the rupture of the connection between the carapace and the abdomen which occurs during the change, but care was taken to replace the parts as nearly as possible in their natural relationship before measurement. In the following Table the sizes of the lobster before and after the moult are set forth. As a rule, the soft lobster was measured within a day or two of the cast. All the lobsters in the Table are females. The lobster is measured from the tip of the rostrum to the hind edge of the telson.

* There was one exception. One female which was berried during the winter cast in the July following. *Vide* p. 87.

No.	Month.	Size (inches) before Casting.	Size (inches) of Soft Lobsters.		Immediate Increase in Size.	Length of Time in Captivity.
			Measured just after the Cast.	Measured after an Interval.		
1	July.	12 $\frac{7}{8}$	12 $\frac{7}{8}$	13	Inch. 0	1 YEAR.
2	"	12 $\frac{1}{2}$	12 $\frac{1}{2}$	12 $\frac{7}{8}$	$\frac{1}{4}$	"
3	"	10 $\frac{5}{8}$	10 $\frac{7}{8}$	..	$\frac{1}{4}$	"
4	"	12 $\frac{3}{4}$	13	..	$\frac{1}{4}$	2 YEARS.
5	"	11	11 $\frac{1}{4}$	..	$\frac{1}{4}$	"
6	"	11 $\frac{1}{2}$	11 $\frac{3}{4}$	..	$\frac{1}{4}$	1 YEAR.
7	"	11 $\frac{1}{2}$	11 $\frac{1}{2}$	..	$\frac{1}{8}$	"
8	"	12	12 $\frac{1}{2}$	..	$\frac{1}{2}$	"
9	Sept.	11	11 $\frac{5}{8}$	..	$\frac{5}{8}$	"
10	"	9 $\frac{1}{2}$	..	10 $\frac{1}{2}$	..	1 month.
11	Oct.	11 $\frac{1}{2}$	12	..	$\frac{1}{4}$	1 YEAR.
12	"	10 $\frac{1}{2}$	11 $\frac{3}{8}$	..	$\frac{5}{8}$	2 months.
13	"	11 $\frac{1}{4}$	11 $\frac{1}{2}$	..	$\frac{1}{4}$	2 "
14	Nov.	11	11	..	0	3 "

These figures indicate that there was no great increase in size just after the cast, whatever may happen during the time that the shell is hardening. Herrick found that the lobster grew considerably during that time. While most of the lobsters mentioned in the Table had been in captivity for a year or more, there are four cases in which the length of confinement was only that of a month or two. In the case of one lobster, the increase in size nine months after the moult was one inch. In the other short-period cases the increase was just as small as with the lobsters which had been over a year in the Laboratory. In two cases, in fact, the soft lobster was, as far as could be ascertained, exactly the same size as the hard lobster. It was not possible to separate all the soft lobsters and measure them subsequently to see what increase took place during the hardening of the shell. In the case of the first two lobsters, which were re-measured, after intervals of two and one week respectively, an increase of $\frac{1}{8}$ inch in each case took place. Ehrenbaum agreed with the earlier observations of Herrick and Rathbun in noting the slowness in the growth of the older lobsters. He instances a case where a lobster, measuring 40.2cm. (16 inches) in length, only increased its length by a millimetre ($\frac{1}{25}$ inch) on casting. Vitzou gives measurements to show the increase that takes place in different parts of the body after casting; he demonstrated the fact that while the carapace and abdomen increased in size at once, the large claws only showed a marked increase 17 hours after the moult.

Salter describes in detail the operation of casting. The lobster cast in July. Immediately after it had got rid of its shell it concealed itself among a mass of seaweed that it had before casting collected in a corner of the tank. Brook observed that a male lobster buried some food before casting, and after another cast it partially buried its cast integument in the sand.

THE HARDENING OF THE SHELL.

The shells of the soft lobsters hardened only very slowly, in this respect differing from cases reported by other observers. A male lobster that cast when in a box floating in Dunbar harbour in July 1902 was 33 days later hard. It had lost nearly all its pereopods, and so had difficulty in walking. It arrived at the Laboratory on September 30th, and lived there until December 30th 1902. Herrick says that six to eight weeks are required to complete the hardening process, a period also given by Prince. Ehrenbaum gives a period of from three to four weeks. Meek records a lobster that, having cast on September 12th, regained its hardness of shell in one month.

The lobsters in the Laboratory were not eager for food immediately after the moult. The food was shelled mussels usually, with fish occasionally. The integument, once it became stiffened, remained for a long time more or less pliable, as if the calcified layer of the shell were poorly developed. Whether the slow hardening is due to the nature of the food or of the sea-water is not known. The shells, many months after the cast, were deficient in lime and cut easily like brown paper.

The lobster that cast on September 22nd 1902 was still soft to the extent that the integument is flexible and yields to pressure, when it died, viz. on June 6th 1903. Another which cast about the middle of August was fairly hard a fortnight later. Three lobsters which moulted in July 1903, and one that moulted in August of the same year, were in the following July 1904 still softish in the shell. They were in good condition, for two of them cast during that month. The fact, then, that their shells had not become as hard as that of the lobsters caught in the sea, did not apparently constitute any weakness in the animals.

A female which cast on 19th October 1903 was fairly hard on December 30th 1903. One of the casters of 1904 was kept until April 2nd 1905, when it was found dead. It was fairly hard, but the carapaces and integument of the abdomen cut easily with a knife. On the shell there was a considerable number of the shells of an annelid. The colour of the carapace was a dull black. It is possible that the food supply is not sufficiently varied to supply all the materials necessary for the building-up of the shell.

One of the lobsters that cast in July 1903 was on October 21st 1904 not very hard. It was found dead on February 17th 1905, and it was then hard.

A female lobster cast in July 1904; on May 6th 1905 it was still rather soft.

The shell of a soft lobster, when put into alcohol, turns red; the colour of the hard shell—blue-black—is not affected by the alcohol.

INDICATIONS OF APPROACHING MOULTING.

When the stock of lobsters was examined on 21st October 1904 one of the lobsters, a female, that had hatched its eggs a month or two previously, attracted attention. The carapace was raised posteriorly and separated a little from the first abdominal joint; the skin between the carapace and the abdomen was bulged out. Ventrally the soft parts between the abdominal segments were turgid. The absorption areas on the chela were a deep bright blue, and yielded a good deal to pressure, showing that absorption of the calcareous layer had been going on there. The lobster was separated from the others, and it cast on November 1st.

On 29th October 1904 a female cast. It had been isolated a short time before. It was then very limp, and half dead in appearance. It was swollen at the junction of the carapace with the abdomen, and somewhat dropsical in appearance. It was not at all smart with its chelæ.

Ehrenbaum says that the lobster merchant is able to distinguish a lobster that is about to cast, by the softening of the ventral edges of the carapace.

THE CAST SHELL.

The colour of the dactyls of the chelæ is noticeable. The back edge of the dactyl is clean and purple in colour, and the pores are well marked. The cast stomach is empty. There is a glairy skin under the carapace, and united to the membranous lining of the integument of the abdomen. It ruptures easily, and is often found sticking out as a fold at the junction of the thorax and abdomen. Vitzou, who witnessed the moulting of the lobster, describes this skin as a homogeneous, gelatine-like layer, which, under the microscope, shows no cellular structure. It is, he says, a secretion of the lower layers of the new carapace; it passes out by endosmose to lie between the old shell and the new integument. Its presence there facilitates the casting.

THE SOFT LOBSTER.

The soft lobster, when just cast, is extremely soft and pliable; the tip of the chela can be made to touch the telson. The stomach is full of little ossicles, which are derived from the breaking-up of the gastroliths. The lobsters at the Laboratory very often failed to rid themselves of their integument. A considerable number died from this cause.

A lobster that moulted on September 22nd 1902 was kept in one of the compartments of a wooden hatching apparatus until October 14th 1902. When in the wooden box it had not eaten food (fish) at all eagerly. It was at the latter date put into a tank, the bottom of which was covered with sand and gravel. It began immediately to eat small pebbles and gravel. Hard lobsters also have been occasionally seen picking up coarse gravel with the pereopods and putting it into their mouths.

When a lobster casts in a tank in which there are other lobsters it is usually attacked by them, sometimes before it has finished casting, and it is sometimes fatally injured. A soft lobster occasionally bleeds to death in consequence of what appear to be comparatively slight wounds. On July 15th a lobster was found to have lost both chelæ in moulting; it had been attacked and had cast off both claws. One chela was shrivelled just as it is when it is first withdrawn from the shell, and before it has swollen out. The other chela had swollen out to its full size. Both claws were cast off at the fracture plane. Couch observed that "the rejection of the limb can be effected with the same ease while the crust remains soft after exuviation." This fact militates against the view that strong rigid supports are necessary round the fracture plane to permit of the defensive mutilation on the part of the crustacean.

In another case a hard lobster had lost one chela, and the other bore the scar of a bite. During moulting the scar prevented the withdrawal of this limb, so it was thrown off at the fracture plane. A bud had formed in place of the previously lost limb, and after the cast a diminutive chela was present; the hand (propodite and dactylopropodite) measured $2\frac{1}{2}$ inches long, while the normal-sized hand measures 4 to 5 inches. Brook

found that the lost smaller pereopods were reproduced to their full size after one cast.

RATE OF GROWTH.

Coste* stated that the lobster begins to reproduce in its fifth year. It casts from eight to ten times in the first year, five to seven in the second, three to four in the third, and from two to three in the fourth. After the fifth year the changes are only annual.

Recent researches on the rate of growth of the European lobster by Appellôf are summarised in a recent number of the *Fish Trades Gazette*.† A lobster, hatched in 1900, cast on 20th June and 5th September 1902, and at the latter date measured $3\frac{1}{4}$ inches long. In the following year it cast on 22nd June and 21st August, its length then being $4\frac{1}{2}$ inches; it was then three years old. Another lobster, when caught in 1901, measured $4\frac{3}{4}$ inches; it cast twice in 1902, and measured 7 inches. In 1903 it cast once, and was then $8\frac{1}{8}$ inches. Appellôf concludes that the lobster on the west coast of Norway takes six or seven years before it reaches a length of $8\frac{1}{4}$ inches, that is to say, maturity. The number of casts which have occurred up to that stage is 17 to 19. Meek concludes that the lobster is 9–10 inches long when four to five years old.

Herrick considered that the American lobster when 10 inches long was about $4\frac{1}{2}$ years old. In the 32nd and 33rd Reports of Commissioners of Inland Fisheries of Rhode Island certain data are given bearing on the rate of growth of that lobster. A method of rearing the larvæ in cloth bags was found to be very successful, a whirling motion was maintained in the water while the lobsters were in the zoea condition. Lobsters were reared from the zoea condition and kept until over two years old. The following are the average sizes at different ages:—

3 months old	..	$1\frac{3}{8}$ inches long.
10 "	.. av.	2 "
1 year	.. "	$2\frac{1}{6}$ "
2 years	.. "	$4\frac{1}{2}$ "
2 years + 4 months	.. "	$4\frac{7}{8}$ "

THE BEHAVIOUR OF THE LOBSTER.

The main motive of a lobster's activity is defence—caution; and, in defending itself, a blind unrelenting vengeance is a fitting corollary. It first procures a hole within which to lie waiting for its prey, and to which it may retire after a foray. Any animal that approaches it is a foe. No animal, lobster or other, is safe to approach and make its presence known. In this highly organised form, its keenness in attack, and relentless hold when it once has gripped its antagonist, are due to its want of sight. The want of sight, in its true sense, in the lobster and crab places a disability on them, and reduces the effectiveness of animals which would otherwise be powerful competitors of the smaller inhabitants of the sea. Herrick says that the eye of the lobster is so sensitive to light that it cannot bear strong light; strong light blinds it. One immediate difficulty then which is experienced in keeping lobsters in confinement is their tendency to fighting, which usually results in the loss of a chela to one of the combatants. When a lobster is seized by its big

* Vide Buckland.

† July 9, 1904.

claw it very often has to yield it up, whereupon the other unconcernedly drops it. Lobsters which have been confined together show many traces of the attentions that have been paid to one another. The chela is, in many cases, missing, or, if it persists, has one or more scars of bites, which had crushed through the shell. Very few of the lobsters have anything but short stumps of their antennæ, these organs having been snipped off more or less close to the head by their companions. These accidents usually happen when the lobsters are wandering about seeking for dark corners and sheltering holes. After they have settled down in their holes they stick to their habitations and do not come so much into competition with one another. When they are first introduced into a tank it is well to have the big claws tied, and by the time the claws work free their owners will have settled down in their new quarters. If there is sufficient accommodation in the form of holes of inviting darkness, they will soon get peacefully distributed; but at first a lobster will sometimes try to evict one lobster from the hole which it has selected as its abode. One lobster was seen to yield up the recess, which was immediately taken possession of by the aggressor.

On each occasion when the tank is emptied for cleaning, and for the purpose of examining the lobsters, it is usually necessary to disturb the shelter-holes, which are formed with stones. When the tank is filled again the lobsters do not seem to recognise one another at once. They go cautiously about seeking shelter, on the watch for foes and ready to fight any lobster they may meet. Under such conditions, then, it is not surprising that chela are lost, or some other injury incurred, before they are all satisfied as to hiding accommodation. When they settle down they allow for one another's presence and get on without quarrelling. This is, of course, due to a healthy respect which they have for one another's fighting powers. The truce is nothing but an armed neutrality. If any one of the lobsters loses its fighting power through casting its shell, it is at once attacked. And that occurs in cases where lobsters have lived together for months. Four lobsters were in a large tank undisturbed for four months. When the tank was emptied each lobster was handled. Two days after the tank had been refilled the chela of one of the inmates was lying loose on the sand.

More especially do the lobsters take advantage of any one of their number that casts its shell. Very seldom does the soft lobster escape without serious injury. Female lobsters attack a soft female. The male which cast in November 1904 was so injured by the female which was with it in the tank that it bled to death. How a male would act towards a female that cast in its presence was not indicated during the experiments, as that case did not occur.

A female lobster that cast on July 13th 1904 had a hard male lobster introduced into the box in which it was. The male did not appear to mind the listless and inactive female; it certainly did not attempt to grasp it or fight it. On July 19th the female was found to have been bitten in the cephalic region; one chela had been lost and one or more of the remaining pereopods bitten off. This is very different treatment to that meted out by the male crab to the moulted female. In the latter case the male protects her.

The extremely defenceless condition of the soft lobster was especially seen in one case. A female that moulted in August had lost both chelæ. It was kept by itself until October, by which time it had become fairly hard. A lobster that had just cast had both chelæ, but was very soft. The two were put together into a small tank. In a few days the soft lobster was found dead; its antennæ, eyes, and part of one chela were eaten off.

Peculiar Action of a Group of Lobsters.

On October 29th the four female lobsters which cast during the summer were very restless. They were walking about in the tank, or standing, as it were, on tip-toes, and having the abdomen bent, with the edge of the telson close up against the fifth pereopod. Occasionally they extended the abdomen and moved the swimmerets backwards and forwards. The male lobster which is with them was also out of his hole, standing on tip-toes, with the abdomen extended straight out and moving his swimmerets actively. The lobsters appeared to be quite friendly, and did not attempt to bite one another. The supply of water running into the tank was not very large at this time. Whether this had in any way influenced the action of the lobsters is an open question. It had not been observed before.

THE SENSES OF THE LOBSTER.

The lobster when it walks has the telson turned in on the abdomen, and it marches on the "points of its toes," backwards as well as forwards. It is practically blind; it sees nothing properly, at least that is the case where it is exposed to the comparatively strong light which during the day illumines the tanks in the Laboratory. It has simply the sensation of light and shadow. It tests a shadow with its antennæ, or sometimes where a strong shadow is thrown on it, it jumps at it with its chelæ outstretched and snapping. It is dependent on its antennæ for guiding it in safe places. It is especially careful in testing any hole before it is satisfied with it. It discovers the cavity by means of its antenna, which is waved well out to the side and in front as it walks. It searches the innermost depths of the hole with the antenna, and then inserts its chela. If the examination with the chela is also satisfactory, it immediately turns and backs smartly into the hole. In feeding it is guided to the food by the antennules. A piece of food which is dropped near a lobster may fall quite unnoticed unless it happens to touch the antenna or the pereopods. It is not seen at all. But sooner or later, according as the distance is short or great, the scent of the food, carried by the currents set up by the exopodites of the maxillipedes, reaches the lobster. The lobster is immediately excited, although previously it was lying quite inert in its hole. It whips the water with its antennules in a staccato fashion, and feels about with the antennæ and chelæ; at first without leaving its hole. At once both antennules are seen to be whipping in the direction in which the food is lying, and an active search is made with the antennæ. If they do not succeed in locating the bait, the lobster rather reluctantly leaves its hole, but cautiously, feeling all round about with its antennæ. It goes off straight in the direction in which the food is lying, and if it misses it with its antennæ and chelæ, walks over it and gets it with its chelate pereopods; it usually picks up its food with the second pereopod. Meanwhile the expected feast has by association stimulated the maxillipedes, which are actively working as if they were already masticating the food. Once the food is seized it is conveyed to the maxillipedes, and the lobster retreats to its hole, there to enjoy its meal. Two lobsters were noticed to have stored up in one case some mussels, in the other a dead sand-eel (*Ammodytes tobianus*), in the inner recesses of their caves.

EFFECT OF COLD ON LOBSTERS.

In the winter the lobsters kept in the tanks of the Laboratory became very sluggish, and ate very little if any food. When taken out of the water and exposed to the frosty air they become very inert.

THE EFFECT OF THE EXPOSURE OF THE LOBSTERS TO STRONG LIGHT.

A number of lobsters have been kept out of doors, in tanks which were without covering. In two of the tanks the bodies of the lobsters were hidden by the wooden shelf which formed the common roof to their pens; one large concrete tank afforded them no cover whatever. In the former the antennae of the inmates were exposed to direct daylight, and they very often had pieces of seaweed and smaller ectozoa growing on them during the summer. Two females were kept in the concrete tank from the autumn of 1902 till September 1903. At the latter date they were completely covered and hidden by a prolific growth of seaweeds, *Laminaria* sp., young mussels, &c., which completely occupied the dorsum of each shell-fish (*vide* fig. 73, pl. iv.). The covering appeared to be of some inconvenience to the lobster in walking. While the growth of the seaweeds was, no doubt, directly due to the exposure to daylight, it is probable that it was permitted by the host as a shelter in the exposed tank. The shells of the pair were clean when they were put into the tank. Herrick records examining a number of lobsters which were adorned with more or less extensive collections of seaweeds and other ectozoa. On none of the lobsters captured in the sea and sent to the Laboratory was there any coat of seaweed. The ectozoa usually consisted of tubes of *Serpula* sp., *Balanus* sp. One of the two cast its shell on 19th October 1903, and a drawing has been made from the cast shell (fig. 73, pl. iv.). It lived until May 1904. The other lobster did not cast, but remained covered with seaweed during the winter; it also was found dead in May 1904.

BODY FLUID.

The body fluid of the lobster is richly albuminous. It is colourless when fresh, but soon congeals on exposure to air to a clear jelly with a slightly brown tint. Alcohol (94 per cent.) causes the blood to coagulate at once.

DISSECTION.—EXAMINATION OF THE OVARY.

Almost without exception, the ovaries of the lobsters examined, measuring 9 inches and over in total length, were found to contain eggs as large, or nearly as large, as ripe eggs. When the eggs are large, yolked, and approaching ripeness the ovary is black in colour; the eggs themselves are black, although the yolk is really a very dark-green colour. The ovary turns red in alcohol.

The lobsters were broadly distinguished as (a) berried, (b) lobsters which had lately hatched their eggs, (c) soft.

(a) *Berried Hens.*

(1) December 21, 1904.—A lobster (from Dunbar) measured $11\frac{1}{2}$ inches in length. The shell was clean. The external eggs were black, showing no pink-coloured part, simply a light-green formative part. The eggs were evidently early. The ovary was white, but contained green eggs measuring .4 and .5 mm. The smaller green eggs contained simply a core of green yolk, surrounded by a periphery of white yolk (by transmitted light). The oviducts were filled with a greenish fluid.

(2) February 19, 1905.—In a lobster (from Dunbar) the external eggs were well advanced; the pink area was about one-fifth of the whole egg. The ovary was large and black in colour.

(b) *Lobsters which were not carrying eggs, but which had HATCHED their eggs in the summer preceding the date of examination.*

(1) December 2, 1902.—Lobster 10 inches long. The shell was dirty, encrusted with *Serpula* sp. The ovarian eggs were large, black, oval in shape, measuring $1.5 \times 1.3 : 1.4 \times 1.3 : 1.35 \times 1.3 : 1.45 \times 1.3$ mm. There were also rows of white eggs between the large eggs. The ovary is mottled here and there on the surface with yellow bodies, which appear to be fat masses.

(2) December 1, 1902.—The ovary of another adult was all over externally of a uniform dull black colour.

(3) December 28, 1902.—A lobster measuring $10\frac{3}{4}$ inches in total length had been two days in formaline before it was examined. The ovaries were large, black, with a tinge of green. There were some white and some yellow small eggs scattered over the surface between the large eggs. The large black eggs measured $1.45 \times 1.35 : 1.32 \times 1.3$ mm. They were polygonal in shape, and stood out boss-like on the surface of the ovary. The smallest yolked eggs were white, the intermediate in size yellow; even some very large eggs were yellow. The yellow colour was probably due to the introduction of the green yolk into the white eggs. From the burst eggs it was seen that the yolk consisted of minute green corpuscles, and also a large quantity of colourless fat corpuscles. The chorion of the egg is very thin and easily ruptures. There were a few small eggs yellowish white in colour measuring $.8 \times .65$ mm. The yellow bodies in the ovary measured about $1 \times .85$ mm. The outer skin of the ovary is very thin.

(c) *Soft Lobsters.*

(1) A lobster that hatched its eggs in the summer of 1903 cast its shell and died during July 1904. It appeared to be well nourished. The ovary was large; the eggs measured $1.75 \times 1.4 : 1.7 : 1.65 \times 1.4 : 1.5$ mm., &c. They were irregular in shape and very soft. A portion of the ovary was cut out and flicked about in sea-water with a camel-hair brush, and the eggs separated easily from the follicular tissue, in which were the yellow bodies noticed above.

(2) A lobster that hatched its eggs in the summer of 1904 cast its shell in September 1904. It was killed by the other lobsters. The ovary was large, dark-green in colour, and friable; the eggs readily detached themselves from the delicate follicular membrane. They were irregular in shape, and measured $1.35 \times 1.15 : 1.15 : 1.9 \times 1.5 : 1.4 \times 1.35 : 1.35 \times 1.25 : 1.3$ mm.

(2-4) Three others which hatched their eggs in 1904 cast and died in October 1904. In each the ovary was large and the eggs apparently ripe.

(5) Another hatcher of 1904 stock was found dead on October 23rd 1904. The ovary was large and full, each egg being sharply separated off from the others. When viewed with a lens the surface of the ovary had a honeycomb appearance. The eggs separate readily from the follicular tissue.

(6) A sixth of this lot was found dead on November 16th 1904. The ovary was large, black, with apparently ripe eggs.

(7) A 1902 hatcher cast in 1903 and also in July 1904; it died immediately after casting. The ovary was to all appearance ripe.

(8) Another 1902 hatcher cast in 1903 and lived till August 1904, when it was killed. On dissection it was found to be in apparently good condition. The ovaries were large, and the eggs appeared to be ready for spawning.

(9) A third specimen of the 1902 stock which had cast in 1903 was kept until February 17th 1905, when it was found dead. The ovary was large and black. The eggs appeared to be ripe, and had at one pole a clear green cap.

(10) The last survivor of the 1902 lot died on April 2nd 1905. It had cast in 1903 and also in 1904. The ovary was large, black; but otherwise the lobster appeared to be poorly nourished.

HARD LOBSTER.

A lobster which was not berried when captured was dissected on December 1st 1903. It measured 11 inches in length. The shell was clean, black. The ovary was black. The eggs were yolked, but only about half the diameter of ripe eggs. The eggs separated fairly freely, and measured $1 \times .8 : .72 \times .65 : 1 \times .9$ mm. These were black yolked eggs. There was also a considerable quantity of white eggs, all small and of various sizes; the largest of those noticed was oval, and measured $.45 \times .3$ mm.

Meek records a lobster measuring $11\frac{1}{2}$ inches in length which hatched its eggs in the beginning of July and lived till September 12th 1901. The ovary was dark green, and was well developed. It exhibited no signs of preparation for casting.

SPAWNING.

Of all the adult female lobsters which have been kept at the Laboratory during the past three years, only one was known to have spawned. Some of those which were from time to time dissected had ovaries which were practically ripe. The lobsters were kept for longer or shorter intervals. One batch of females which were berried in 1902, and which hatched their eggs in the summer of that year, were represented at the Laboratory till April 1905. No member of this group showed any eggs attached externally. That they were not altogether unhealthy was shown by the fact that they nearly all moulted once, in two cases twice, during the period named. So it was with the other females; they cast readily, but did not succeed in spawning, or, if they spawned, the eggs did not become attached. Moreover, none of those dissected had a spent ovary. In the case of the adult crabs some spawned, but in one or two of these only a few eggs became attached.

The lobster which became berried was received from Dunbar in December 1902, at which time it was not berried. It cast its shell on September 2nd 1903. On January 13th 1904, when it was examined, it was not berried, but on July 14th a small quantity of eggs were found attached to the swimmerets. The eggs were early and apparently just spawned; they were dark-green with a clear granular area on one side. This lobster was not with a male lobster when it spawned. On October 21st 1904 there were only two eggs remaining attached, and when it was examined on November 19th 1904 the remaining two had disappeared.

As to the time when spawning takes place, Ehrenbaum gives the period covering July, August, and probably September. Fullarton obtained lobsters with very early eggs—yolk unsegmented—between July 18th and August 25th. Herrick says, for the American lobster, that the definite spawning season is the summer, July and August, but that a minority extrude their eggs in the fall and winter, if not also in the spring. Allen obtained females with freshly extruded eggs during the latter half of July. Appellöf agrees with the period announced by

Ehrenbaum, but extends it to the middle of October. Meek found newly-spawned lobsters in July and August. The lobster which spawned during Cunningham's experiments in Cornwall did so in October, and Scott's specimen extruded its eggs during the same month at Piel Laboratory.

There is thus indicated an extended spawning season, including the months of July, August, September, and October. It may be that there are here two distinct groups of spawners—summer and autumn spawners—the first including lobsters that were not berried during the winter immediately preceding, while the autumn spawners are those which were berried during the winter, hatched their eggs in the summer, and extruded another batch of eggs in the autumn.

The question whether or not the European lobster may carry external eggs two years in succession does not arise, Cunningham's observation, confirmed later by Scott's description of the process, having demonstrated that possibility. As for the American lobster, Herrick maintains, in a later work, the position taken by him on this question in 1895. He founds his contention that the American lobster does not carry eggs externally two years in succession on the condition of the ovary in various lobsters which had lately hatched the eggs. He maintains that the ovary requires two years to develop to ripeness.

The factors which determine the spawning of the lobster are obscure. It is remarkable that only one lobster spawned in the Laboratory, although in several cases the ovaries of specimens which were dissected were apparently ripe. The rate of development of the ovary is dependent on some factor that is not apparent. The ovaries referred to would probably have been completely ripe in a short time. The complete ripening seemed to be inhibited by some influence, which might have been the absence or insufficiency of male lobsters. Even where a male lobster was present with the female spawning did not take place, and when the one lobster spawned no male was present. Otherwise the lobsters, it may be inferred, were under comparatively suitable conditions, for there was a uniformity shown in their history while in confinement. Moulting was common. What is the reason for the abstention from spawning? The artificially-supplied food may have induced growth rather than reproduction.

The lobster may spawn the same year in which it has cast its shell. Trybom's experiments* in labelling lobsters in order to determine their migrations indicated two females, measuring $8\frac{1}{2}$ inches long, liberated in June, had in November cast their shells and spawned; they then measured a little over 9 inches in length.

The actual modus of spawning has been described by Coste, Scott, and others.

Ehrenbaum describes a condition of the lobster which follows when a ripe lobster has been prevented from spawning. The eggs are absorbed and the blood becomes dark green or black in colour. The dark blood shows through at certain parts of the body and the lobster is known as a black lobster. Lobsters in this condition are found among those confined in floating boxes. The ovaries are much reduced in size, and the majority of the eggs have lost the green yolk, and have become of a yellowish colour.

The Ripe Egg and the Formation of the Perivitelline Space.

The ripe egg, newly spawned, was measured by Scott and found to be 1.8mm. in diameter.

**Fish Trades Gazette*, July 30, 1904.

During the examination of the ovaries of the lobster no case was found in which the eggs showed a perivitelline space when in the ovary. Large ovarian eggs, however, as a rule, develop a perivitelline space if left some time in sea-water. A lobster that cast on July 9th 1904 died five days later. The ovarian eggs measured $1.75 \times 1.4 : 1.7 : 1.65 \times 1.4 : 1.5\text{mm}$. The eggs were teased out in sea-water and two or three hours afterwards showed considerable perivitelline spaces. The space usually shows more on one side than on the other; it is clear and colourless.

A lobster that hatched its eggs in the summer of 1904 and cast immediately afterwards was dead on October 23rd 1904. Some ovarian eggs were separated and put into sea-water. An hour afterwards the eggs, in most cases, showed a more or less well-marked perivitelline space. Next morning the eggs kept in the sea-water overnight had very large perivitelline spaces. The eggs were yellow—dead.

The egg of the lobster has two envelopes:—(1) Outside—the chorion. (2) Within the chorion, and closely applied to the egg—the vitelline membrane. This envelope is well seen sometimes when a perivitelline space has been developed in sea-water.

The External Eggs.

When the eggs are just spawned they are of a deep greenish black in colour, with a little clear area at one pole. As development proceeds, the clear area becomes pink in colour, and by the month of October in some lobsters the future limbs and the black pigmented eyes were already made out. The transparent pink area steadily grows larger at the expense of the black yolk, until, when the eggs are nearly ready to hatch, the black yolk may be reduced to half, or even much less, of the mass of the egg. The black yolk occupies the cephalic and gastric regions in the larva.

The external eggs measured on May 17th were of the following dimensions:— $2.2 \times 2 : 2.15 \times 2.1 : 2.1 \times 2.05 : 2.25 \times 1.95 : 2.25 \times 2 : 2.15 \times 2 : 2.1 : 2.1 : 1.95 \times 1.9 : 1.95\text{mm}$. The eggs are, for the most part, oval. They were well developed, the pink area being about one-fifth of the whole mass of the egg. In some of the eggs examined in June the black yolk had disappeared; most of the eggs showed a large mass of black yolk.

When ready to hatch, the eggs are of various colours, viz. transparent pink, transparent blue, transparent green, except for the black area which marks the yet unused-up yolk. The largest eggs show the least black area; in them the black has practically disappeared. The eggs increase greatly in size before hatching, and at that time it is difficult to dissect them off the swimmerets without rupturing the zona radiata. The following measurements of various eggs were made in August 1902; the eggs were, as a rule, distinctly oval in shape:—

Pink egg,* 2.5mm .; pink eggs, $2.8 \times 1.95 : 2.4 \times 2.15 : 2.35 \times 2.25\text{mm}$.

Egg, blue and yellow, $2.5 \times 2.45 : 3.2 \times 2.55 : 2.9 \times 2.4\text{mm}$.

Egg, deep blue, $2.35 \times 2.3\text{mm}$.

Egg, red, $2.05 \times 1.9 : 2.9 \times 2.6 : 3.15 \times 2.8 : 2.8 \times 2.6\text{mm}$.

In the last egg the heart of the embryo was seen beating.

The Number of External Eggs.

Buckland calculated the number of eggs borne by a female. He first counted the number on one foot and from that deduced the total. This was 24,960 eggs. Ehrenbaum found that the larger the

* Zona ruptured.

lobster the larger the number of eggs which it carried. A lobster 10 inches long had 8000 eggs, while one 15 inches in length bore 32,000. Herrick found in the American lobster that the number of eggs varied from 3000 to 70,000. The eggs of two lobsters were estimated at the Laboratory in the following manner:—They were snipped off the swimmerets and dried in a water-bath. A small portion was detached and weighed, the number of eggs in it was counted, and the total number was got from the total weight. One measuring $11\frac{1}{2}$ inches in length, 11,300 eggs, while the other, $12\frac{1}{2}$ inches long, had the same number.

It is remarkable that so small a number of fry was obtained from the parent lobsters kept in the Bay of Nigg. This is partly accounted for from the fact that a greater or less quantity of the eggs is lost when the berried hens are handled, and during transport. This does not, however, seem sufficient to account for the whole of the shortage.

HATCHING.

Hatching occurred at the Laboratory during July, August, and September. The earliest larvæ appeared about the middle of July, the majority hatched in August, and a few in September.

According to Coste* hatching takes place in March, April, and May. Allen records that hatching took place in one instance in March. Fabre-Domergue, and Biérix† observed the hatching of the lobster, and describe the process in detail. The larvæ issue early in the night.

The whole brood of any one female does not hatch out at once, but over a period, the larvæ issuing in two or more batches (*vide* Coste, Herrick, and Fullarton). The incubation period, according to Ehrenbaum, Herrick, and Fullarton, is about eleven months. During an incubation period so extended it is to be expected that a certain variation will have occurred in the point of development reached by different eggs. This would result in spreading the hatching of the eggs over a period which probably does not usually exceed a fortnight or three weeks. The first larval lobsters were observed on July 11th, and one of the females was found to have hatched all her eggs on August 2nd. The larvæ usually appeared in the morning.

MEASUREMENTS OF THE LOBSTER.

Occasionally lobsters are measured by the length of their barrels, *i.e.* of the carapace, from the extremity of the rostrum to the hind border. In several cases the relation between the total length and the length of the barrel has been noted, and the data are entered below.

Total Length of Lobster.	Length of Barrel.
♀ $9\frac{1}{2}$ inches.	$4\frac{3}{16}$ inches.
♀ $10\frac{5}{8}$ "	$4\frac{7}{8}$ "
♀ 11 "	$4\frac{3}{4}$ "
♀ $11\frac{1}{2}$ "	$5\frac{1}{16}$ "
$12\frac{1}{2}$ "	$5\frac{1}{2}$ "
♂ 13 "	$5\frac{5}{8}$ "

* *Vide* Buckland.

† *Fish Trades Gazette*, Sept. 26, 1903.

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LIST OF LETTERS AND FIGURES USED.

I., Ia., II., III., “IV.”=First to “Fourth” Zoëa Stages.

1, 2, 3, 4, 5, 6, 7=Joints of Limb, viz. (1) Coxopodite, (2) Basipodite, (3) Ischiopodite, (4) Meropodite, (5) Carpopodite, (6) Propodite, (7) Dactylopodite.

a.—Antennule.
A.—Antenna.
ab.—Abdomen.
en.—Endopodite.
ep.—Epipodite.
ex.—Exopodite.
lr.—Labrum.
1m.—First maxilla.

2m.—Second maxilla.
Mn.—Mandible.
mp.—Maxillipede.
o.—Eye.
1-5 per.—First-Fifth Pereiopods.
Pleo.—Pleopod.
T.—Telson.
Th.—Thorax.

EXPLANATION OF PLATES.

PLATE I.

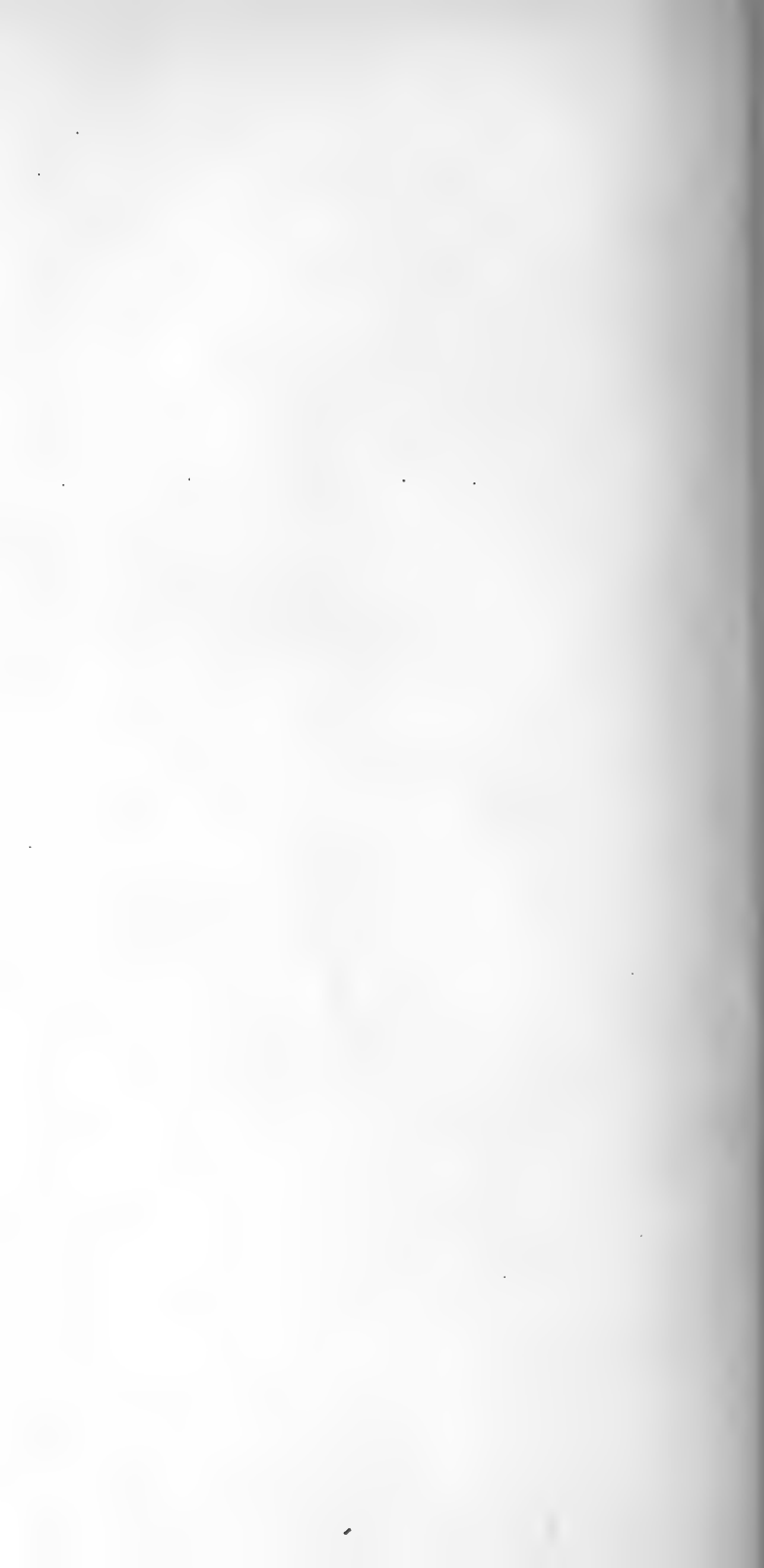
All the Figures are of the First Zoëa.

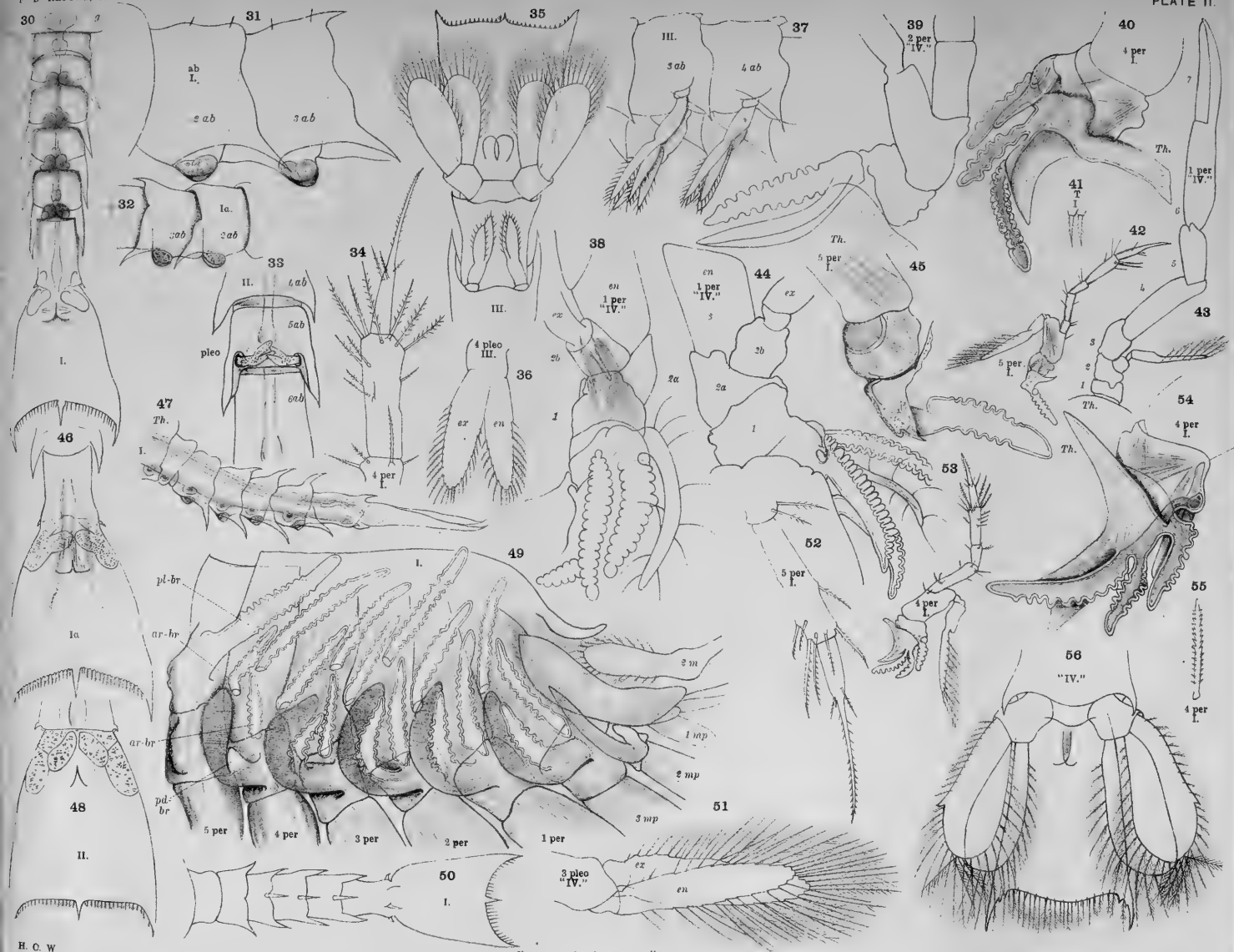
Fig. 1.	Antenna and antennule,	×	47
Fig. 2.	Antennule,	×	57
Fig. 3.	Labrum,	×	62
Fig. 4.	Eye and rostrum,	×	33
Fig. 5.	Mandible,	×	33
Fig. 6.	Cutting edge of mandible,	×	120
Fig. 7.	First maxillipede,	×	62
Fig. 8.	Third maxillipede,	×	33
Fig. 9.	Second maxilla,	×	57
Fig. 10.	Palp (?) of first maxillipede,	×	175
Fig. 11.	First pereopod (chela),	×	19
Fig. 12.	First protopodite joint and gills of the second pereopod,	×	62
Fig. 13.	Third pereopod,	×	19
Fig. 14.	Epipodite of second maxillipede,	×	220
Fig. 15.	First protopodite joints and gills of the second pereopod,	×	62
Fig. 16.	Third maxillipede,	×	33
Fig. 17.	Propodite and dactylopodite joints of the third pereopod,	×	62
Fig. 18.	Palp of mandible,	×	120
Fig. 19.	Protopodite of the second maxillipede,	×	62
Fig. 20.	Propodite and dactylopodite joints of the chela (first pereopod),	×	62
Fig. 21.	Propodite and dactylopodite joints of the second pereopod,	×	62
Fig. 22.	Second pereopod,	×	19
Fig. 23.	Edge of endopodite of the first maxillipede,	×	175
Fig. 24.	Flagellum of antenna,	×	57
Fig. 25.	First protopodite joint of the third pereopod,	×	62
Fig. 26.	First protopodite joint of the third pereopod (second view),	×	62
Fig. 27.	First maxilla,	×	62
Fig. 28.	Protopodite of the chela (first pereopod),	×	33
Fig. 29.	Second maxillipede,	×	33

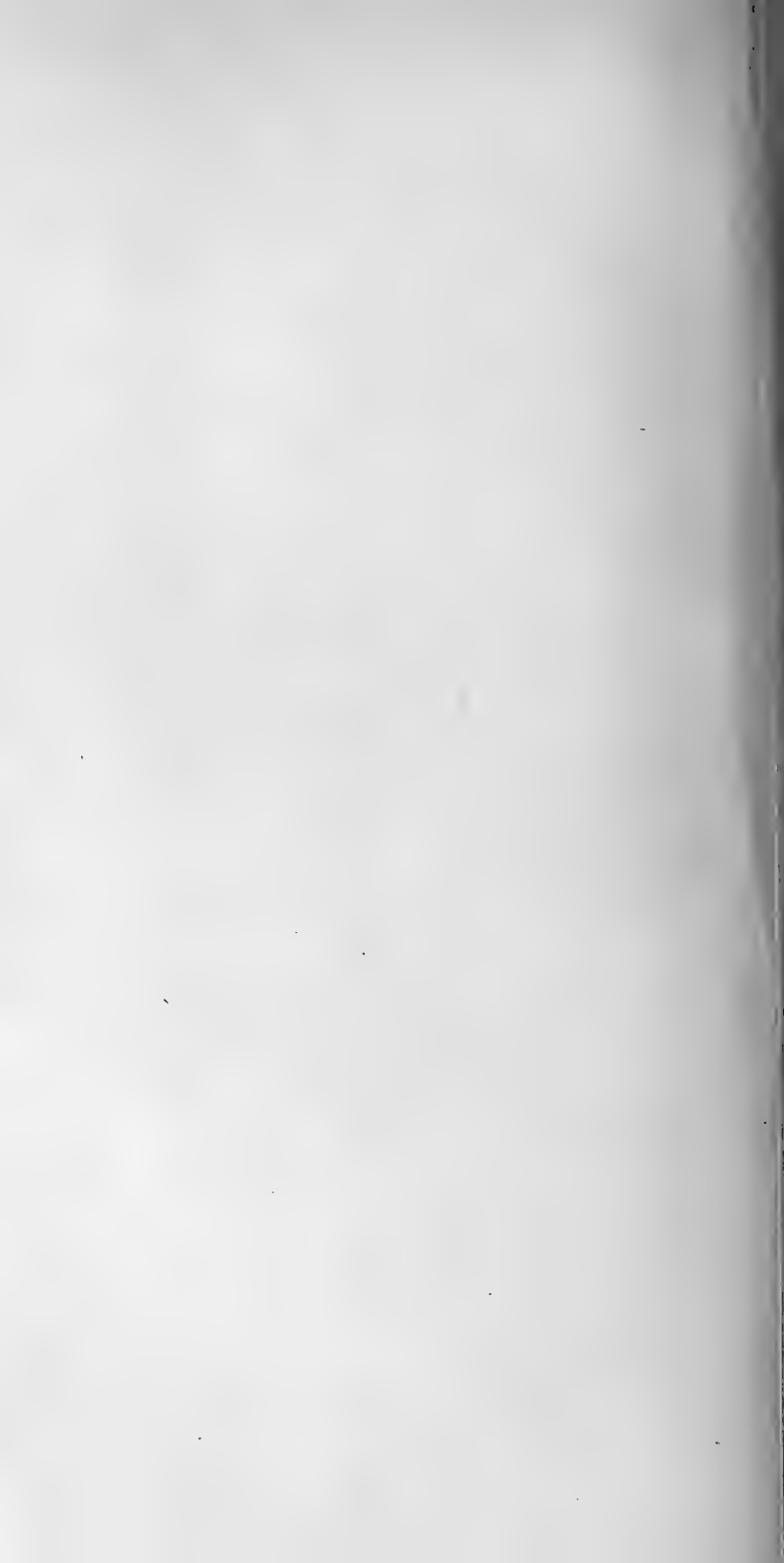
PLATE II.

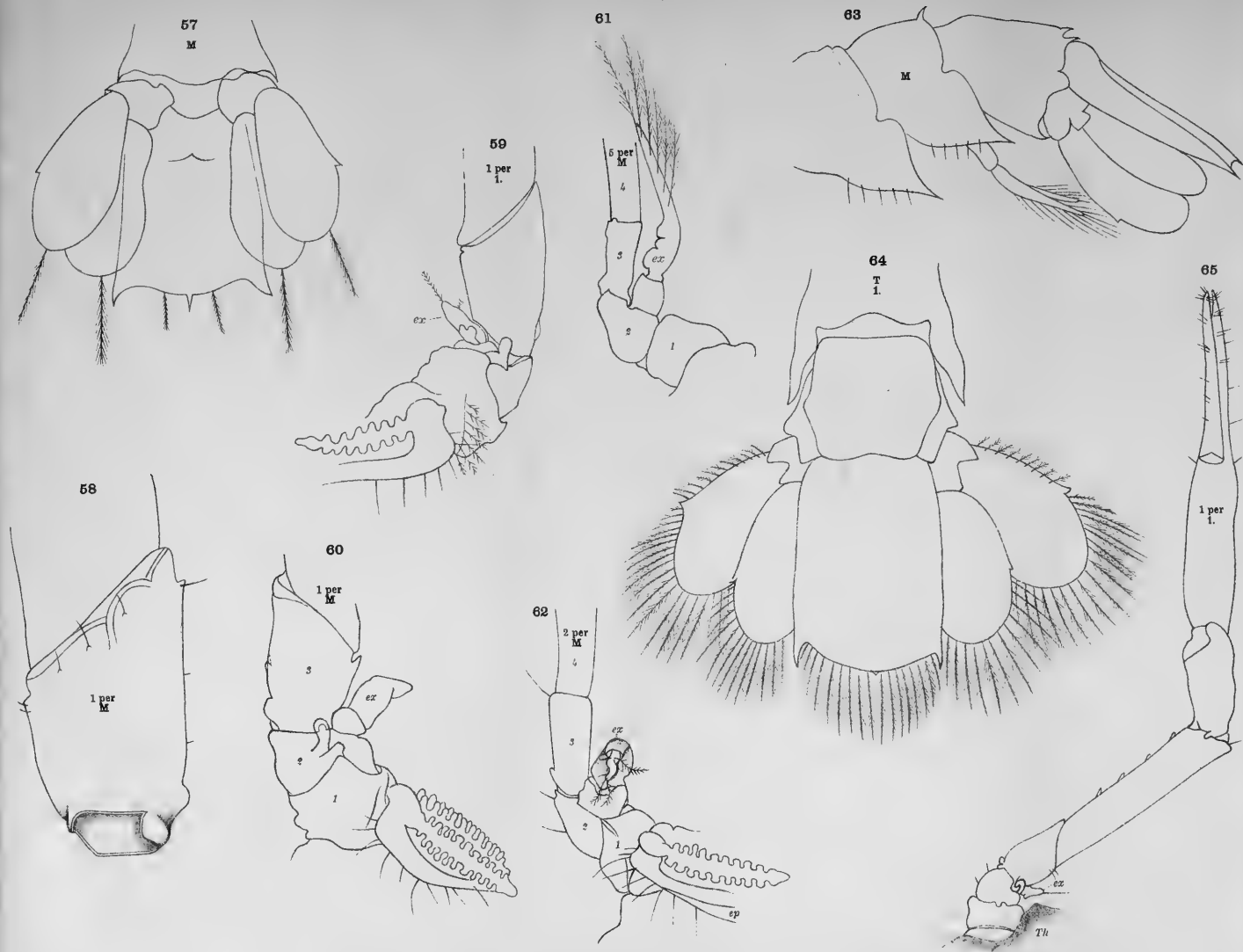
Fig. 30.	Abdomen, zoëa, first stage, ventral view, g =ganglion,	×	19
Fig. 31.	Abdomen, 2nd and 3rd joints, zoëa, first stage, side view,	×	44
Fig. 32.	Abdomen, 2nd and 3rd joints, zoëa, stage 1a, side view,	×	19
Fig. 33.	Abdomen, 5th joint, zoëa, second stage, ventral view,	×	19
Fig. 34.	Propodite and dactylopodite joints of the fourth pereopod, zoëa first stage,	×	62
Fig. 35.	Telson, zoëa, third stage, ventral view,	×	19
Fig. 36.	Cast 4th pleopod of zoëa, third stage,	×	33
Fig. 37.	Abdomen, 3rd and 4th joints, zoëa, third stage,	×	19
Fig. 38.	Protopodite joints of first pereopod, zoëa, "fourth" stage, $2a+2b$ =2nd protopodite joint,	×	33
Fig. 39.	Protopodite joints of second pereopod, zoëa, "fourth" stage, magnified.		
Fig. 40.	First protopodite joint of fourth pereopod, zoëa, first stage, magnified.		
Fig. 41.	Setæ of hind border of telson, zoëa, first stage,		magnified.
Fig. 42.	Fifth pereopod, zoëa, first stage,	×	19
Fig. 43.	First pereopod, zoëa, "fourth" stage,		
Fig. 44.	Protopodite joints, first (1), second ($2a+2b$), en =endopodite, ex =exopodite, zoëa, "fourth" stage,	×	33
Fig. 45.	Protopodite, first joint, fifth pereopod, zoëa, first stage,	×	62
Fig. 46.	Telson, zoëa, 1a stage,	×	19
Fig. 47.	Abdomen, side view, zoëa, first stage,	×	15
Fig. 48.	Telson, zoëa, second stage, a =anus,	×	19
Fig. 49.	Side of thorax, zoëa, first stage, showing the arrangement of the gills.		
Fig. 50.	Abdomen, zoëa, first stage, dorsal aspect.		
Fig. 51.	Third pleopod, zoëa, "fourth" stage,	×	57
Fig. 52.	Propodite and dactylopodite joints of fifth pereopod, zoëa, first stage,	×	62
Fig. 53.	Fourth pereopod, zoëa, first stage,	×	19
Fig. 54.	First protopodite joint, fourth pereopod, zoëa, first stage,	×	62
Fig. 55.	One of the serrated spines on propodite of fourth pereopod, zoëa, first stage.		
Fig. 56.	Telson, zoëa, "fourth" stage, ventral view,	×	11

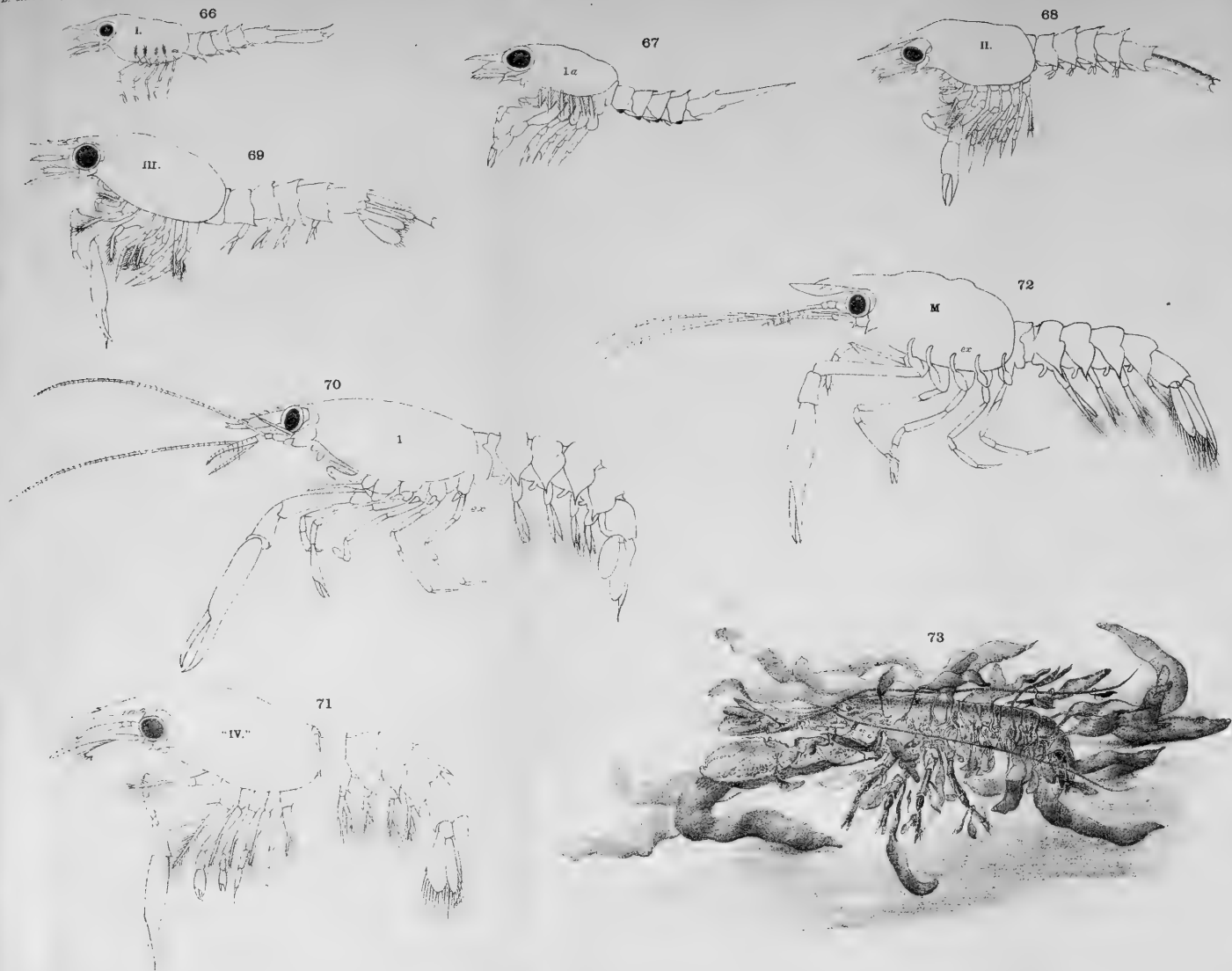












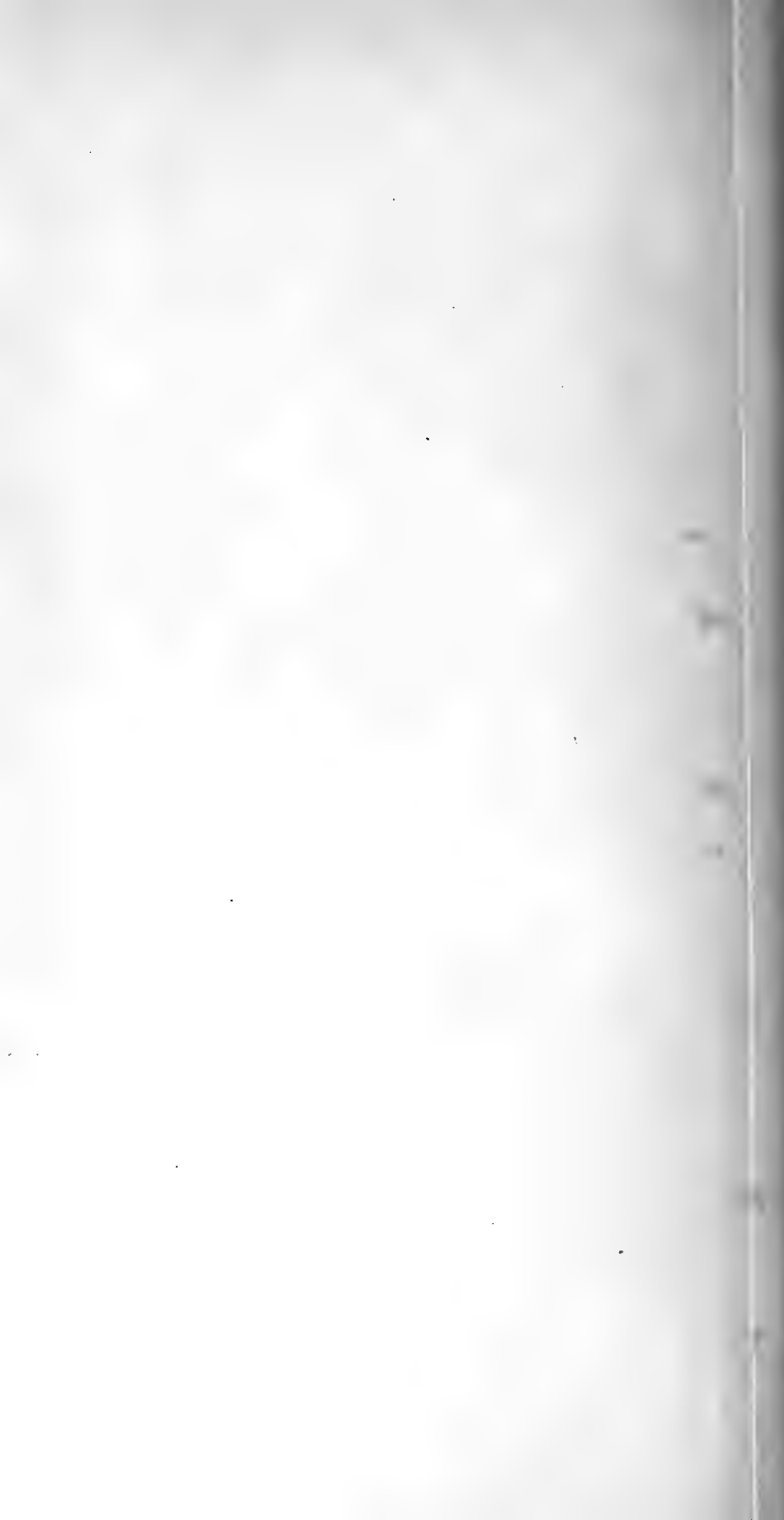


PLATE III.

Fig. 57. Telson, megalops. All the setae are not filled in,	.	.	×	19
Fig. 58. Fracture end of first pereopod, megalops.	.	.	.	
Fig. 59. Protopodite joints of first pereopod, first young stage,	.	.	×	33
Fig. 60. Protopodite joints of first pereopod, first young stage (second view),	.	.	×	33
Fig. 61. Fifth pereopod (part of), megalops,	.	.	×	33
Fig. 62. Second pereopod (part of), megalops,	.	.	×	33
Fig. 63. Telson, megalops, side view,	.	.	×	19
Fig. 64. Telson, first young stage, dorsal view,	.	.	×	15
Fig. 65. First pereopod, first young stage,	.	.	×	15

PLATE IV.

Fig. 66.	Zoëa, first stage,	.	.	.	.	.	x	7
Fig. 67.	Zoëa, 1a stage,	.	.	.	.	.	x	7
Fig. 68.	Zoëa, second stage,	.	.	.	.	.	x	7
Fig. 69.	Zoëa, third stage,	.	.	.	.	.	x	7
Fig. 70.	First young stage,	.	.	.	.	.	x	7
Fig. 71.	Zoëa, "fourth" stage,	.	.	.	.	.	x	7
Fig. 72.	Megalops,	.	.	.	.	.	x	7
Fig. 73.	Adult lobster covered with growth of seaweeds, mussels, &c.,	.	.	.	.	.	reduced.	

III.—OBSERVATIONS ON SOME PARASITES OF FISHES NEW OR RARE IN SCOTTISH WATERS.

BY THOMAS SCOTT, LL.D., F.L.S., &c.

Plates V. and VI.

In Part III. of the Twenty-second Annual Report of the Fishery Board for Scotland, I published a small paper on some parasites of fishes new to the Scottish marine fauna. Since the issue of that paper several other rare and interesting species have been examined, and these I now propose to describe.

The species to be described belong for the most part to the Copepoda; but there are also five species belonging to the Trematoda. As these parasitic Copepoda and Trematoda are quite distinct groups, my observations on them are, as in the previous paper, divided into two parts, viz., Part I. Copepoda parasita, and Part II. Trematoda.

I have been indebted for several of the species described here to Dr. H. C. Williamson; Mr. Bowman and Mr. Irvine have also obtained a few interesting species for me. Canon A. M. Norman has also allowed me the privilege to examine one or two rare Copepoda in his collection, sent to him many years ago from the Moray Firth by the late Thomas Edward of Banff.

My son, Andrew Scott, A.L.S., has prepared the drawings which illustrate this paper.

PART I.—COPEPODA PARASITA.

FAMILY ERGASILIDÆ.

Genus *Bomolochus*, Nordmann (1832).

Bomolochus soleæ, Claus.

This species of *Bomolochus* has quite recently been obtained in the nostrils of *Gadus luscus*, which adds another to the number of fishes now known to harbour these Copepods in their nostrils. It was in the nostrils of *Cyclopterus lumpus* that the first specimens were observed, early in 1909, but soon afterwards they were obtained in the nostrils of some other fishes, and notably in those of the cod *Gadus morhua*, where they appear to be of quite frequent occurrence. The fishes in whose nostrils the copepods have been most commonly obtained are those belonging to the gadidæ. The following are the names of the fishes:—*Cyclopterus lumpus* L., the Lumpsucker. *Gadus morrhua* L., the Cod-fish. *Gadus aeglefinus* L., the Haddock. *Gadus merlangus* L., the Whiting. *Gadus luscus* L., the Brassie. *Gadus pollachius* L., the Lythe. *Molva molva* L., the Ling. *Pleuronectes platessa* L., the Plaice, and *Pleuronectes flesus* L., the Flounder. *Bomolochus soleæ* was first found on the back of the common Sole—*Solea vulgaris*, Quen.

FAM. CALIGIDÆ.

Genus *Caligus*, O. F. Müller (1785).**Caligus abbreviatus*, Kröyer. Pl. v., figs. 1-6.1863. *Caligus abbreviatus*, Kr., Bidrag til Kundskab om Synltekrebsene; Naturh. Tidsskr., 2R., 2B., p. 61, pl. iii., fig. 3, a-k.

Description of the Female.—The Female represented by the drawing, (fig. 1) measures 5mm. ($\frac{1}{5}$ of an inch). The cephalic shield is nearly circular in outline, but is rather widest behind the middle; the width of the frontal plate is scarcely half the width of the cephalic shield at the widest part; lunulæ very clearly defined. Abdomen and furcal joints very short, as represented in the drawing.

The antennulæ have the basal joints robust and broadly sub-triangular, but the end joints are long and narrow (fig. 3).

The second maxillipeds are robust, and form powerful grasping organs (fig. 5).

The sternal fork, which is moderately stout, and the branches of which are not greatly divergent, has a resemblance to the same appendage in *Lepeophtheirus Thompsoni*, Baird (fig. 4).

The fourth pair of thoracic legs are elongated; the basal joint is moderately stout and one-branched; this branch is slender and composed of two joints, and the end-joint is about twice the length of the first, and is armed with a long, slender and claw-like terminal spine and a short spine near the distal end of the outer margin; the first joint is also furnished with a spine on the outer distal angle (fig. 6).

Habitat.—On a Ballan Wrass, *Labrus bergylla*, captured in the Moray Firth in October 1904, and on another fish of the same species captured in the North Sea. Kröyer also obtained his specimens of the *Caligus* on the Ballan Wrass.

A young specimen representing the *Chalimus* stage of this *Caligus* is represented by figure 2, and was obtained along with the adult form. In this specimen the siphon is still present, showing a somewhat dilated and biarticulated base; the antennulæ are composed of two short subequal joints, the cephalic shield is elongate-ovate in outline, and the abdomen is very short. The frontal plate slopes posteriorly, and the development of the lunulæ is considerably advanced.

Caligus minimus, A. W. Otto.1828. *Caligus minimus*, Otto, Nova Acta Acad. Cæs. Leop., vol. xiv., p. 354, pl. xxii., fig. 7.1840. *Caligus minutus*, M. Edw., Hist. Nat. Crust., vol. iii., p. 450.1901. *Caligus minimus*, A. Scott, Trans. Liverpool Biol. Soc., vol. xv., p. 349, pl. i., figs. 1-8.

Habitat.—On a Bass, *Labrax lupus*, captured above Queensferry on February 4, 1903. This appears to be the first record of *C. minimus* for the Forth district.

* This species closely resembles, and is probably identical with, *Caligus centrodonti*, Baird. (Cf. Brit. Entom., p. 272-3, Tab. xxxii., figs. 6, 7.)

Genus *Pseudocaligus*, A. Scott (1901).*Pseudocaligus brevipedis* (Bassett-Smith).

1896. *Caligus brevipedis*, Bassett-Smith, Ann. and Mag. Nat. Hist. (6), vol. xviii., p. 11, pl. iii., fig. 1.

1901. *Pseudocaligus brevipedis*, A. Scott, Trans. Liverpool Biol. Soc., vol. xv., p. 350, pl. ii., figs. 1-4.

Habitat.—Found attached to the base of the tongue of a Three-bearded Rockling, *Onos tricirratus*, captured at the mouth of the River Dee, Aberdeen, November 23, 1904. Eight specimens of a *Bomolochus*, probably *B. onosi*, were also found on the same fish adhering to the gills and gill-arches.

Genus *Lepeophtheirus*, Nordmann (1832).*Lepeophtheirus sturionis*, Kröyer. Pl. v., figs. 7-14.

1837. *Lepeophtheirus sturionis*, Kr., Tidsskrift, i., Tab. vi., fig. 6.

Description of the female.—The female of this species has a general resemblance to that of *Caligus diaphanus*, Nordmann, but is much larger, being fully half an inch in length (about 14mm.).

The cephalic shield is nearly circular in outline, and the frontal plate, which is not very prominent, is without lunulæ.

The last thoracic segment is considerably shorter than the cephalic shield, and is only slightly longer than broad.

Abdomen moderately narrow and elongated, being equal to nearly three-fourths the length of the last thoracic segment. Furcal joints very short (fig. 7).

The basal joints of the antennules are considerably dilated, and the end joints though short are also tolerably stout (fig. 8).

Antennæ robust and armed with a large and strong claw, the distal end of which is bent at nearly a right angle, as shown in the drawing (fig. 9).

The mandibles resemble those of *L. pectoralis*, O. F. Müller.

The basal-joint of the second maxillipeds is moderately stout and elongate, and armed with a short but strong terminal claw (fig. 11).

The "palpi," though slightly dilated at the base, have the sides nearly parallel, and the two branches of the bifid extremity are tolerably elongated (fig. 10); the small appendage at the bases of the palpi bear each one moderately large spine and two small ones, as shown in the drawing.

Sternal fork very stout and with triangularly divergent branches (fig. 12).*

Fourth pair of thoracic legs stout, each with a single three-jointed branch; the outer distal angle of the first joint in each branch terminates in a small tooth, a stout spine springs from the outer distal angle of the second joint, while the end joint is armed with three terminal spines of varying lengths (fig. 13).

The short furcal joints bear a few small apical setæ or spines (fig. 14).

Habitat.—Taken from a Sturgeon, *Acipenser sturio*, Linn., captured about 16 miles S.E. by E. of Aberdeen, and landed at the Fish Market, Aberdeen, on December 29, 1904. I am indebted to Mr. Bowman, Aberdeen, for this addition to the marine copepod fauna of Scotland.

*Kröyer in Naturh. Tidsskr. 1 Band (1837), Pl. vi., fig. 66, shows the ends of the branches of the sternal fork slightly bifid; but the figure in Naturh. Tidsskr. 3 R., 2 B. (1863), Pl. xvii., fig. 4, represents the sternal fork of another form bluntly pointed at the ends, and with which our figure is identical.

FAM. DICHELESTIIDÆ.

Genus *Dichelestium*, J. F. Hermann (1804).*Dichelestium sturionis*, Hermann. Pl. v., figs. 17-24; pl. vi., figs. 1-6.1804. *Dichelestium sturionis*, Herm., Mém. Aptérolologique, p. 125, Tab. v., figs. 7-8.1837. *Dichelestium sturionis*, Kröyer, Naturh. Tidsskr., 1st B., p. 299, Tab. ii, figs. 5 and 5a (♀).

Description of the Female.—The length of the female represented by the drawing (pl. vi., fig. 1) is 17.8mm (nearly $\frac{3}{4}$ of an inch). Body elongated and narrow; cephalic segment nearly as broad as long, widest behind the middle, sides angulated, truncate, and obscurely trilobed in front. Thoracic segments four, first and second subequal, length equal to about half the breadth, and narrowly rounded at the sides; third segment rather shorter than the one which follows, and each with a shallow transverse suture that divides it into two slightly unequal portions. Genital segment narrow, and about one and a half times the length of the one which immediately precedes it; the ultimate segment ovate, small, being scarcely half the length of the genital segment. Furcal joints short. Ovisac long and slender (pl. vi., fig. 1).

Antennules short, slender, and apparently composed of eight subequal joints (pl. v., fig. 17).

Antennæ robust, extremities chelate, and forming powerful grasping organs (pl. v., fig. 18).

The mandibles resemble those of *Caligus* or *Lepeoptheirus* very closely, but differ in having a stouter basal part, and in the long slender rod-like portion being only three-jointed, the last joint being coarsely serrated on the inner edge (pl. v., fig. 20).

Maxillæ small, two-branched; primary branch stout, tapering distally and furnished with two slender apical setæ; secondary branch very small (pl. v., fig. 21).

The first maxillipeds appear to be three-jointed. The first joint, which is large and tolerably dilated, is about as long as the next two combined; the distal end of the second joint is fringed with short bristles, and the end joint, which is very small, is furnished with a short terminal claw, and a few small marginal spines are shown in the drawing (pl. v., fig. 22).

The second maxillipeds, short, very robust and strongly chelate (pl. v., fig. 23).

The thoracic legs are short and stout. The first and second pairs are two-branched. The branches of the first are indistinctly two-jointed, and the outer branches are furnished with a small spine on the outer distal angle of the first joint, while the end-joint bears five moderately stout spines on its rounded extremity; the inner branches bear each two terminal spines (pl. vi., fig. 3). The second pair are rather more dilated than the first, and both branches are similarly armed (pl. vi., fig. 3).

The fourth pair is composed of a single uniaarticulate branch in the form of an elongated lamelliform plate which bears a few minute teeth round the distal end (pl. v., fig. 24).

The male, which resembles the female, but is considerably smaller, being scarcely half an inch in length, and the genital segment is also proportionally shorter (pl. vi., fig. 2); there is also a difference in the second and fourth pairs of thoracic legs, as shown in the drawing (pl. vi., figs. 5 and 6). In other respects the male is very similar to the female.

Habitat.—Taken from a sturgeon, *Acipenser sturio*, captured about 16 miles S.E. by E. of Aberdeen and brought into the Aberdeen Fish Market, December 29, 1904. The same species of *Dichelestium* has also been found by my son, Andrew Scott, on the gills of a sturgeon captured near Barrow-in-Furness, Lancashire. I am indebted to Mr. Bowman of Aberdeen for this further addition to the marine copepod fauna of Scotland.

The structure of the mouth organs, and especially of the mandibles, indicates a close relationship of *Dichelestium* with the Caligidæ.

Genus *Anthosoma*, Leach (1816).

Anthosoma crassum (Abilgaard). Pl. v., figs. 15 and 16.

1794. *Caligus crassus*, Abgd., Mém. de Copenhagen, Act. Soc. Nat. Havn.

1837. *Anthosoma Smithi*, Krøyer, Naturh. Tidsskr., 1st B., p. 295, Tab. ii., figs. 2 and 2a (♀).

1850. *Anthosoma Smithi*, Baird, Brit. Entom., p. 296, pl. xxxiii., fig. 9.

1861. *Anthosoma crassum*, Steenstrup and Lütken, Bidrag til Kundskab, p. 397, pl. xxii., fig. 24 (♂).

This interesting species was found on a shark, supposed to be a Porbeagle shark, *Lamna cornubica*, captured off the coast of Scotland by one of the trawling steamers that make only short runs from Aberdeen. The steamer, which captured the shark in October 1904, is one of those belonging to Mr. Davidson, Aberdeen, and is locally known as a "short tripper." Two specimens of the *Anthosoma* were obtained; one of them is a female with ovisacs, the other, which is smaller, is probably a male. The drawings, figures 15 and 16 on plate v., represent a dorsal and ventral view of the female. This specimen measured about 15 millimetres exclusive of the ovisacs, and about 62 millimetres—nearly 2½ inches—to the extremity of these appendages.

The female, which is tolerably elongated, appears, when seen from above to be of an ovate outline; it is narrow in front, and a brownish horny shield, which gradually expands towards the posterior end, covers the head and a considerable portion of the thorax; an obscure constriction marks the junction of the head with the thorax; two large foliaceous elytraform, circular plates, the inner margins of which partly overlap each other on the dorsal aspect, cover entirely the remaining portion of the thorax not covered by the dorsal shield, and also the abdomen and furcal joints. These plates are ornamented by numerous minute scattered punctures or depressions, as shown in the drawing (fig. 15).

The antennules are short, slender, and composed of six joints which are very sparingly setiferous; but the antennæ—described by Baird as the first pair of footjaws—are strong and powerful; they are longer than the antennules and composed of three joints, and armed with strong, terminal, hook-like claws.

The first maxillipeds are slender and feeble, and appear to consist of three joints; they are provided with a small, terminal, claw-like spine.

The second maxillipeds are short, very stout and powerfully clawed.

The thoracic legs are in the form of thin and broadly foliaceous plate, each having a distinct notch on the inner margin.

The abdomen is short and the furcal joints narrow and moderately elongated, as in figure 16, which shows the ventral aspect of the specimen.

The shield is of a chitinous texture, of a brownish colour on the sides,

but merging into blackish brown along the middle and towards the proximal end; the elytraform plates and thoracic feet, which also appear to be chitinous, are whitish with a slight tinge of yellow.

I am indebted to Mr. Irvine for the opportunity of examining and describing this interesting species.

Drs. Steenstrup and Lütken in the work referred to above give a series of excellent figures illustrative of the structure of the male of *Anthosoma*, and it would appear from the description and figures of these authors that the large foliaceous and elytraform dorsal plates which cover the posterior part of the female are absent in the male.

FAM. LERNÆIDÆ.

Genus *Pennella*, Oken.

Pennella filosa (Linne).

1754. *Pennatula filosa*, Linn., Syst. Nat. et. Amœn. Acad., vol. iv.
 1767. *Pennatula filosa*, Linn., Syst. Naturæ, Ed. 12, vol. ii., pp. 13-22.
 1870. *Pennella Orthogorisci*, E. P. Wright, Ann. and Mag., Nat. Hist. (4), vol. v., p. 42, pl. 1.

The Rev. Canon A. M. Norman, to whom I am often indebted for information and help in Natural History research, has, with his usual kindness, permitted me to examine a specimen of this curious copepod parasite which he received many years ago from the late Thomas Edward of Banff, who found it on a short sunfish, *Orthogoriscus mola*, in the Moray Firth. The species is recorded in Smiles' Life of Edward, among the many other Natural History rarities mentioned at the end of that work, under the name of *Pennella fibrosa*. Linnæus in his 12th Edition of Systema Naturæ, referring to the host of *Pennella filosa*, says, "Habitat in M. Mediterranei Xiphiis."

Genus *Lernæa*, Linné (1767).

Lernæa luscii, Bassett-Smith. Pl. vi., fig. 18.

1896. *Lernæa luscii*, Bassett-Smith, Ann. and Mag. Nat. Hist. (6), vol. xviii., p. 13, pl. iv., fig. 6.
 1904. *Lernæa luscii*, T. Scott, 22nd F.B. Rept., Pt. III., p. 277, pl. xvii., fig. 12 and 13.

A *Lernæa* apparently belonging to this species was found adhering to a small *Gadus luscus* sent to the Laboratory from the fish market at Aberdeen on January 12, 1905. The various species belonging to the genus *Lernæa* fix themselves to the gills or gill-arches of the fishes infested by them, but the specimen now recorded had its head buried in the flesh of the fish some distance behind the operculum, as shown in the drawing (fig. 18). This is the first example of the kind I have met with.

FAM. CHONDRACANTHIDÆ.

Genus *Sphyrion*, Cuvier (1830).

Sphyrion lumpi, Krøyer.

1863. *Lesteira lumpi*, Kr., Bidrag til Kundskab, Nat. Tidsskr., BR. 2 B., p. 325, Tab. xviii., fig. 5, a-g.

Sphyrion lumpi, T. Scott, 19th F.B. Rept., Pt. III., p. 128, vol. vii., fig. 13.

A fine specimen, the most perfect I have seen of this curious species, was presented to me by Mr. Irvine of Aberdeen; it was obtained by him on one of a number of catfishes, *Anarrhicas lupus*, landed at Aberdeen Fish Market from a Norwegian trawler. The fishes were captured in about 200 fathoms, and therefore beyond the limits of the Scottish area. An imperfect specimen was taken from a Lump sucker captured in April 1900 in the nets of the salmon fishers near the Laboratory at Bay of Nigg, Aberdeen, and is described and figured in Part III. of the Nineteenth Annual Report of the Fishery Board for Scotland.

Genus *Chondracanthus*, De la Roche (1811).

Chondracanthus depressus, sp. n. Pl. vi., figs. 7–13.

Description of the Female.—This species resembles in its general appearance the *Chondracanthus flurce* of the Long Rough Dab, *Drepanopsetta platessoides*, but it is more depressed. The cephalon, which is sub-quadrangular, is scarcely as long as broad, the next two segments are also wide and very short, while the last thoracic segment is distinctly constricted in the middle and very depressed; it is broader in proportion to its length than the same segment in *Chondracanthus flurce*, being about as broad as it is long. The postero-lateral processes are somewhat narrow, cylindrical, and sigmoid, and curved inward so as to approach close to each other, and sometimes overlap (fig. 8). The abdomen is very short.

The specimen represented by the drawing (fig. 7) measures about 5 mm. ($\frac{1}{5}$ of an inch), exclusive of the ovisacs, which are tolerably short and thick.

The antennules are short and very robust; they are simple in structure; and the distal extremity, which appears to be obscurely jointed, bears scattered apical spinules (fig. 9).

The antennæ are somewhat similar to those of *Chondracanthus cornutus*.

The mandibles, which are stout, moderately elongated, and strongly curved, taper gradually to the attenuated distal extremity; they are each armed with a row of small but moderately stout denticles along each margin, as shown in the drawing (fig. 10).

The first maxillipeds are greatly dilated at the base, and the terminal joint, which is also stout, tapers to a blunted apex, the internal margin is coarsely toothed on the distal half (fig. 11).

Thoracic feet two pairs, short, stout, and bifid, or with two rudimentary branches; both branches are stout, but the outer is shorter and scarcely so much dilated as the inner. Though the first pair are as robust as the second they are scarcely so long; the two branches in both pairs are covered more or less with minute prickles, as shown in the drawings (figs. 12 and 13).

Habitat.—On the gills of the Flounder, *Pleuronectes flesus*, captured in the Firth of Forth and St. Andrews Bay.

This form differs from any of the species previously described by the very short anterior thoracic segments and by the last segment being depressed and of a broadly quadriform outline, as well as by the structure of the thoracic legs.

A form which appears to be a variety of the species just described, and which has also been observed on the same kind of fish, differs in being rather more elongated and less depressed. The antennules are larger, with a slightly different armature; the two pairs of thoracic legs are also larger and more robust, and the inner branches more distinctly triangular

in outline. Only one or two specimens of this form have yet been observed, and as it resembles *Chondracanthus depressus* in some respects I record it for the present as variety *oblongus* of that species (see figs. 14-17, pl. vi.).

FAM. LERNÆOPODIDÆ.

Genus *Brachiella*, Cuvier (1817).

Brachiella triglæ, Claus

1901. *Brachiella triglæ*, T. Scott, 19th F.B. Rept., Pt. III., p. 133, pl. vii., figs. 24-29.

Habitat.—Obtained on the gills of a Streaked Gurnard, *Trigla lineata*, captured at Station VIII., Firth of Forth, in September, 1897, but only now recorded. The Forth is a new station for this species.

PART II.

ON SOME SPECIES OF TREMATODA NOT PREVIOUSLY RECORDED.

The ecto-parasitic vermes of fishes are not uncommon, but as many of them, and especially of the Trematoda, are of small size and more or less flattened, and as their colour approximates closely to that of the fishes on which they live, they are readily missed when the fishes are being examined.

There is evidently a considerable variety of forms among these Trematodes. That some of them are elegant in outline as well as in structure is shown by the beautiful drawings in MM. van Beneden and Hesse's work, *Recherches sur les Trématodes Marins*.

In the following notes I record a few curious forms exhibiting some peculiarities of structure which differ somewhat from those described in previous papers on these organisms, published in Part III. of the Annual Reports of the Fishery Board for Scotland for 1895, 1901, 1902, and 1904. I also give at the end of the present paper a list of all the species recorded in these various Reports.

TREMATODA.

FAM. POLYSTOMATIDÆ.

Genus *Phyllocotyle*, van Benden and Hesse (1863).

Phyllocotyle gurnardi, van Beneden and Hesse. Pl. vi., figs. 19 and 20.

1863. *Phyllocotyle gurnardi*, v. Ben. and Hesse, Rech. sur les Trém., p. 103, pl. x., fig. 1-7 (not *Phyllocotyle gurnardi*, T. Scott in Part III. of the 19th Report, p. 147, pl. viii., fig. 23).

Under this name I record a species of Trematode found on the gills of specimens of the Grey Gurnard (*Trigla gurnardus*, Lin.) from the Moray Firth.

The body of this Trematode is lanceolate, very flat, and moderately slender at the anterior end, but becomes wider posteriorly; the distal end is rounded, and furnished on the ventral aspect with six marginal suckers of moderate size and of a rather complicated structure—three on each margin; an elongated process, slender and narrow, and with

parallel sides, springs from the rounded end; this process is armed at the extremity with four hooked teeth, the two outer teeth are large and strong, with an expanded base, but the other two are smaller and more slender (fig. 20).

According to the authors of the *Recherches*, this species when extended measures about 5 mm., but in the specimen represented by the drawing (pl. vi., fig. 19, of this paper), the body is considerably contracted in length, and is consequently wider, the peduncle at the posterior end, which when fully extended is very slender and narrow, is also shortened in the specimen figured. This peduncle is very fragile, and is therefore occasionally incomplete, and for that reason, and also because it can be folded back under the body of the animal, it may at times easily escape being noticed.

Genus *Plectanocotyle*, Diesing.

Plectanocotyle Lorenzii, Monticelli.

1899. *Plectanocotyle Lorenzii*, Monticelli, Di una nova Specie del genere *Plectanocotyle*; Atti. R. Acad. delli Sci. di Torino, vol. xxxiv., p. 1, pl. 1 (separate copy).

1901. *Phyllocotyle gurnardi*, T. Scott, 19th F.B. Rept., Pt. III., p. 147, pl. viii, fig. 23.

A Trematode recorded by me under the name of *Phyllocotyle gurnardi* in the Nineteenth Annual Report of the Fishery Board for Scotland (1901), was afterwards recognised as belonging to a species described by Dr. F. R. Sav. Monticelli two years previously under the name mentioned above.

This *Plectanocotyle* had been obtained by Dr. Lorenz some years before on a species of Gurnard, *Trigla* sp. The slender posterior peduncle, so characteristic of *Phyllocotyle gurnardi*, is apparently absent in *Plectanocotyle*. The Scottish specimens from *Trigla gurnardus* were examined by Dr. F. R. Sav. Monticelli, and recognised by him as belonging to the species he had described in 1899.

As already pointed out, the peduncle in *Phyllocotyle*, being so slender and fragile, is easily damaged, and when it gets torn off or folded under the body, and when the body is shortened by contraction—a contingency not uncommon when fishes infested by the parasites are preserved in spirit or formaldehyde—the one Trematode may easily be mistaken for the other.

Genus *Microcotyle*, van Beneden and Hesse (1863).

Microcotyle donavani, van Beneden and Hesse. Pl. vi., fig. 21.

1863. *Microcotyle donavani*, v. Ben. and Hesse, *Recherches*, p. 114, pl. xii., figs. 1–11.

This species was found on the gills of a Ballan Wrasse (*Labrus bergyllta*, Ascan.), obtained by Dr. H. C. Williamson in the Moray Firth on October 23, 1904, and also on a Ballan Wrasse captured in the North Sea by Mr. Bowman.

The species is narrow and elongated, and at the posterior end there is a row of small suckers along each margin; the number of suckers in each row appears to vary to a small extent. In the specimen represented by the drawing (fig. 21) the number in each row is about thirty-four.

Microcotyle donavani does not appear to be a rare form; the authors of the *Recherches* state that it has been found in abundance on the

same species of *Labrus* in the month of March. Several specimens were found on the gills of the *Labrus* from the Moray Firth and from the North Sea, but none were very perfect. This species of *Microcotyle* is not only very slender, but is also without consistence, and therefore easily injured. The length of the specimen represented by the drawing is 5.3mm. Figure 22 is a front view of one of the suckers seen under a moderately high magnification.

Microcotyle labracis, van Beneden and Hesse. Pl. vi., fig. 21.

1863. *Microcotyle labracis*, v. Ben. and Hesse, Recherches, p. 112, pl. xii., figs. 12-18.

This species has a general resemblance to *M. donavani*, but differs in possessing about double the number of suckers at the posterior end (fig. 21). The structure of the œsophagian bulb also differs in the two species.

The length of the specimen represented by the drawing is about 7mm.

Habitat.—On the gills of the Bass, *Labrax lupus*. I am indebted to my son for specimens of this species.

FAM. GYRODACTYLIDÆ.

Genus *Diplectanum*, Diesing (1858).

Diplectanum æquans, Diesing. Pl. vi., fig. 24.

1858. *Diplectanum æquans*, Diesing, Revis. der Myzhelm., p. 77.

1863. *Diplectanum æquans*, v. Ben. and Hesse, Recherches, p. 122, pl. xiii., figs. 9-22.

This Trematode is common on the gills of the Bass, *Labrax lupus*, but being very small it is easily missed. The length of the specimen represented by the drawing (fig. 24) is about 2mm.

In *Diplectanum æquans* the head is armed with two moderately strong hooked spines on each side of a deeply concave cleft; this cleft is occupied by a process thickly covered with minute prickles, as shown in the drawing.

I am indebted to my son for this small but interesting species.

The following is a list of species belonging to the Trematoda that have been described or recorded, and for the most part figured, in Part III. of the Annual Reports of the Fishery Board for Scotland. The species now recorded are included in the list. The names are arranged in alphabetical order.

Name of the Species.	Annual Report where published, and Number of Plate where figured.
<i>Acanthocotyle monticellii</i> , T. Scott, -	20th Report; Pl. xiii.; 1902.
<i>Anthocotyle merluccii</i> , v. Ben. and Hesse, -	19th „ Pl. viii.; 1901.
<i>Callocotyle krøyeri</i> , Diesing, -	„ „ „ „
<i>Dactycotyle pollachii</i> , v. Ben. and Hesse, -	„ „ „ „
<i>Diplectanum æquans</i> , Diesing, -	Present Report; Pl. vi.
<i>Epidella hippoglossi</i> , O. F. Müller, -	19th Report; no figure.
<i>Heterocotyle pastinacæ</i> , T. Scott, -	22nd „ Pl. xvii.; 1904.

Name of the Species.	Annual Report where published, and Number of Plate where figured.
<i>Microcotyle donavani</i> , v. Ben. and Hesse,	Present Report; Pl. vi.
" <i>labracis</i> , " "	
<i>Octobothrium alosæ</i> (Hermann), -	19th Report; Pl. viii.; 1901.
" <i>esmarkii</i> , T. Scott, -	" " No figure.
" <i>harengi</i> , v. Ben. and Hesse,	" " Pl. viii.; 1901.
" <i>scombræ</i> , Kuhn, -	13th " Pl. iv.; 1895.
" <i>merlangi</i> , Kuhn, -	19th " Pl. viii.; 1901.
<i>Onchocotyle appendiculata</i> , Kuhn, -	Present Report; Pl. vi.
<i>Phyllocotyle gurnardi</i> , v. Ben. and Hesse,	19th Report; Pl. viii.; 1901.
<i>Phyllonella soleæ</i> , " "	
* <i>Plectanocotyle lorenzi</i> , Monticelli, -	" " " "
<i>Pterocotyle morrhue</i> , v. Ben. and Hesse,	" " " "
" <i>palmata</i> , Leuckart, -	22nd " Pl. xvii.; 1904.
<i>Thaumatocotyle concinna</i> , T. Scott, -	19th " Pl. viii.; 1901.
<i>Tristoma mole</i> , Blanchard -	" " " "
<i>Trochopus lineatus</i> , T. Scott, -	" " " "
<i>Udonella caligarum</i> , Johnston, -	" " " "

* Described in 1901 as *Phyllocotyle gurnardi*.

DESCRIPTION OF THE PLATES.

PLATE V.

Caligus abbreviatus, Kröyer.

Diam.

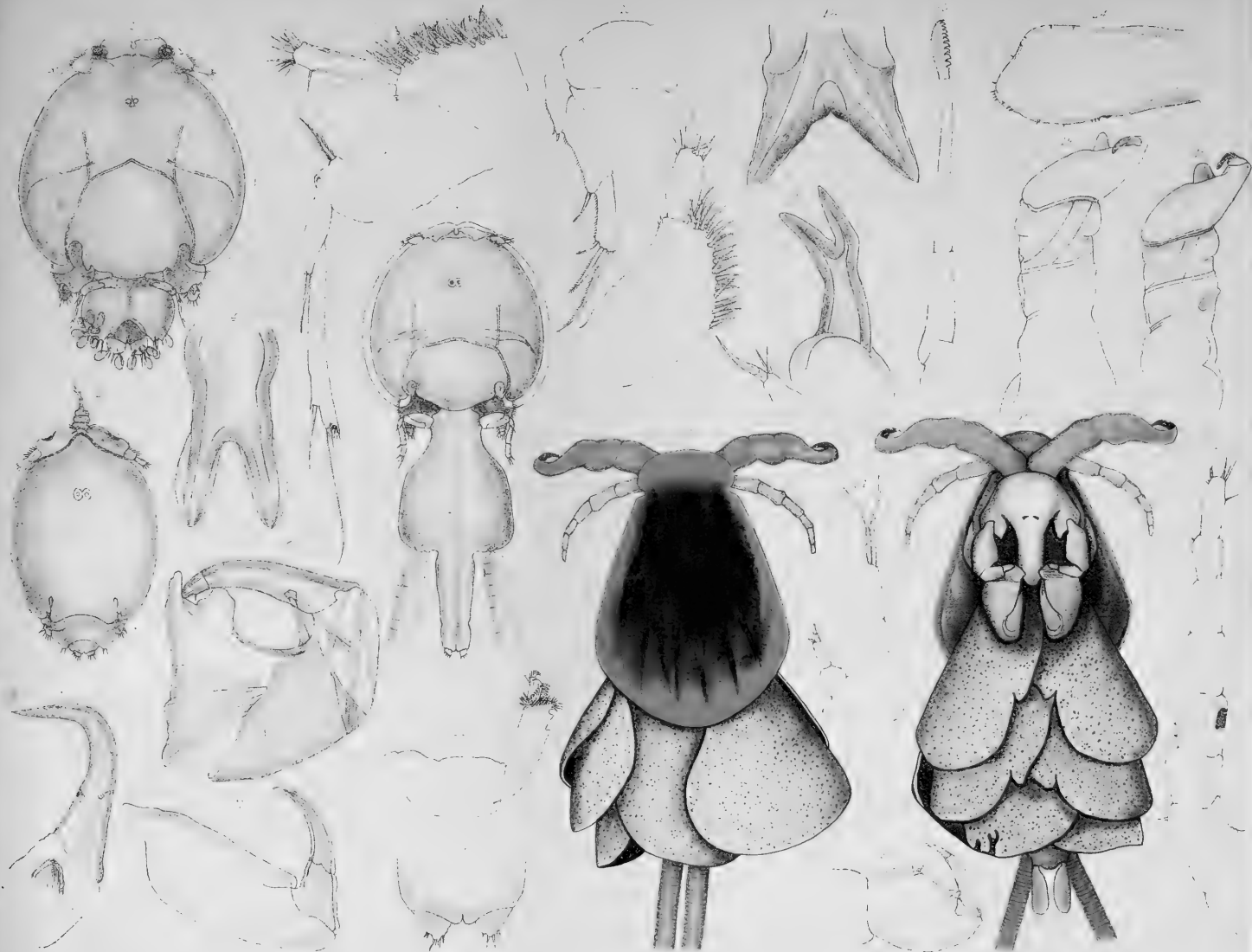
Fig. 1.	Female, dorsal view	.	.	.	.	.	×	14.
Fig. 2.	Female, young	.	.	.	.	.	×	27.
Fig. 3.	Antennule	.	.	.	.	.	×	72.
Fig. 4.	Sternal fork	.	.	.	.	.	×	120.
Fig. 5.	Second maxilliped	.	.	.	.	.	×	45.
Fig. 6.	Foot of fourth pair	.	.	.	.	.	×	108.

Lepeophtheirus sturionis, Kröyer.

Fig. 7.	Female, dorsal view	.	.	.	.	.	×	6.6.
Fig. 8.	Antennule	.	.	.	.	.	×	72.
Fig. 9.	Antenna	.	.	.	.	.	×	45.
Fig. 10.	One of the "palpi"	.	.	.	.	.	×	67.5.
Fig. 11.	Second maxilliped	.	.	.	.	.	×	45.
Fig. 12.	Sternal fork	.	.	.	.	.	×	90.
Fig. 13.	Foot of fourth pair	.	.	.	.	.	×	28.
Fig. 14.	Last segment of abdomen and furcal joints	.	.	.	.	.	×	31.

Anthosoma crassum, Abgld.

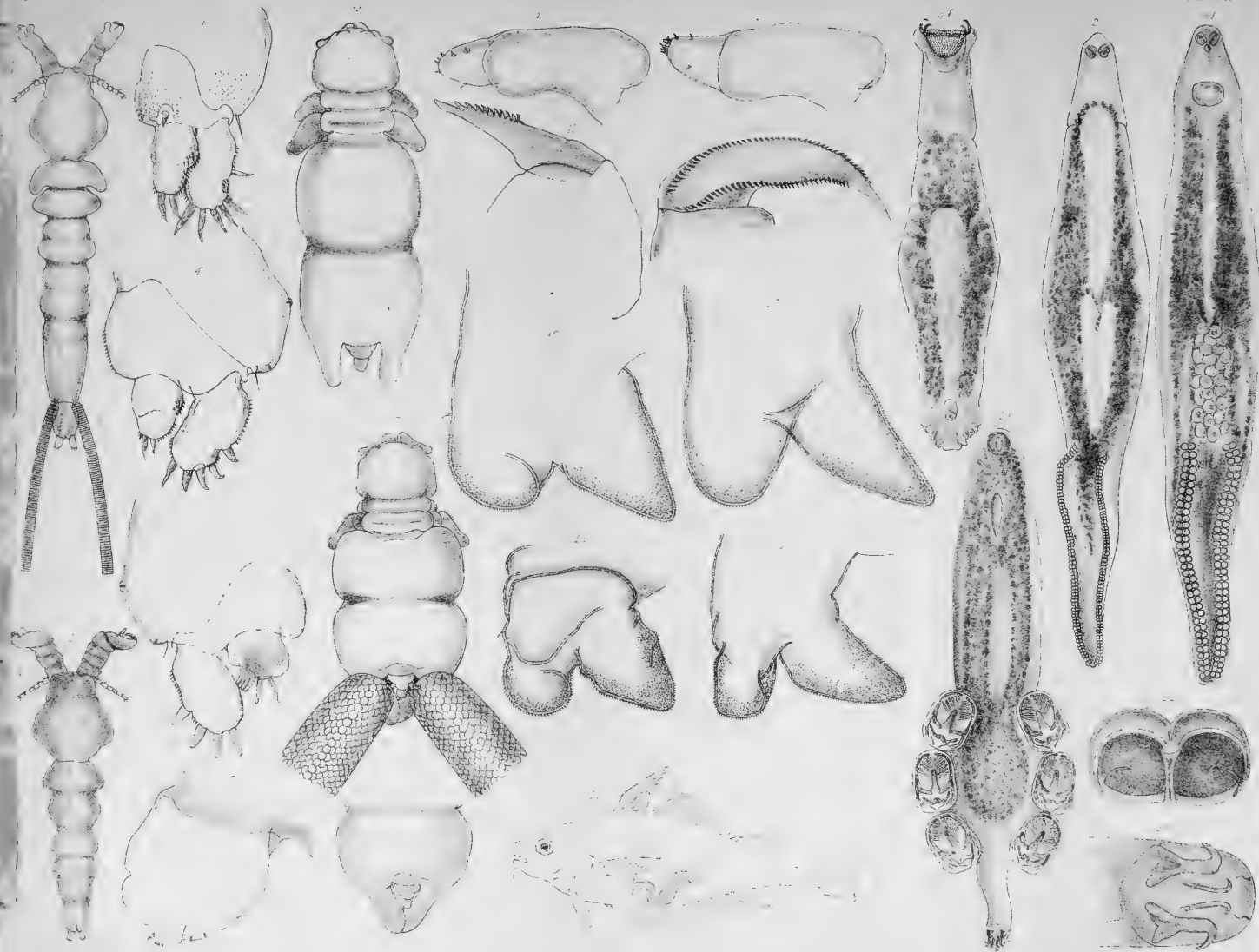
Fig. 15.	Female, dorsal view	×	6.
Fig. 16.	Female, ventral view	×	6.



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Dichelestium sturionis, Hermann.

Fig. 17.	Antennule, female	×	46.
Fig. 18.	Antenna, female	×	17.
Fig. 19.	Antenna, male	.	.	.	.	.	.	×	17.
Fig. 20.	Mandible	.	.	.	.	.	.	×	60.
Fig. 21.	Maxilla	.	.	.	.	.	.	×	46.
Fig. 22.	First maxilliped, female	.	.	.	.	.	.	×	23.
Fig. 23.	Second maxilliped, female	.	.	.	.	.	.	×	15.
Fig. 24.	Foot of fourth pair, female	.	.	.	.	.	.	×	28.

PLATE VI.

Dichelestium sturionis, Herm.

Fig. 1.	Female, dorsal view	.	.	.	.	.	.	×	4.6.
Fig. 2.	Male, dorsal view	.	.	.	.	.	.	×	4.6.
Fig. 3.	Foot of first pair, female	.	.	.	.	.	.	×	46.
Fig. 4.	Foot of second pair, female	.	.	.	.	.	.	×	46.
Fig. 5.	Foot of second pair, male	.	.	.	.	.	.	×	46.
Fig. 6.	Foot of fourth pair, male	.	.	.	.	.	.	×	24.

Chondracanthus depressus, sp. n.

Fig. 7.	Female, dorsal view	.	.	.	.	.	.	×	Diam. 12.
Fig. 8.	Posterior appendages of same	.	.	.	.	.	.	enlarged.	
Fig. 9.	Antennule	.	.	.	.	.	.	×	60.
Fig. 10.	Mandible	.	.	.	.	.	.	×	260.
Fig. 11.	First maxilliped	.	.	.	.	.	.	×	260.
Fig. 12.	Foot of first pair	.	.	.	.	.	.	×	55.
Fig. 13.	Foot of second pair	.	.	.	.	.	.	×	55.

Chondracanthus depressus, var. *oblongus*.

Fig. 14.	Female, dorsal view	.	.	.	.	.	.	×	12.
Fig. 15.	Antennule	.	.	.	.	.	.	×	60.
Fig. 16.	Foot of first pair	.	.	.	.	.	.	×	55.
Fig. 17.	Foot of second pair	.	.	.	.	.	.	×	55.

Lernæ lusci, Bassett-Smith.

Fig. 18.	Gadus lucus with parasite <i>in situ</i>	reduced.	
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Trematoda.

Fig. 19.	<i>Phyllocotyle gurnardi</i> , v. Ben. and Hesse	×	45.
Fig. 20.	Extremity of peduncle of the same	×	260.
Fig. 21.	<i>Microcotyle donavani</i> , v. Ben. and Hesse	.	.	.	.	.	.	×	27.
Fig. 22.	The same—one of the posterior suckers	.	.	.	.	.	.	×	390.
Fig. 23.	<i>Microcotyle labracis</i> , v. Ben. and Hesse	.	.	.	.	.	.	×	18.
Fig. 24.	<i>Diplectanum æquans</i> , Diesing	.	.	.	.	.	.	×	45.

IV.—REPORT ON THE OPERATIONS AT THE MARINE HATCHERY, BAY OF NIGG, ABERDEEN, IN 1904. By Dr. T. WEMYSS FULTON, F.R.S.E., Superintendent of Scientific Investigations.

During the season of 1904 the operations at the Marine Hatchery were continued in connection with the hatching of the eggs of the plaice, as in previous years, and a number of lobsters were also dealt with. The hatching apparatus and the various ponds in connection with the establishment continue to perform the work for which they were intended in a satisfactory manner. An account of these and of the methods employed in the collection of the eggs and their treatment in the hatchery has been given in some of the previous reports, to which reference may be made for the detailed description.

It need only be said here that the adult fishes which act as the brood stock are confined throughout the year in a large tidal pond, where they are regularly fed, almost entirely with common mussels, and that at the spawning-time the fertilised eggs, shed freely into the water, are collected daily, or almost daily, by means of a large net of mosquito netting, and are then transferred to the incubating apparatus in the hatchery.

The duration of the period of development, until hatching takes place, varies according to the temperature of the water at the time; the period is longer at the beginning of the spawning season, when the temperature is low, than towards the end of the season, when the temperature has risen considerably. At the beginning of the work in January the average time of incubation before the eggs hatch is about three weeks, while at the end of the season they hatch in about a fortnight. The larval fishes, after they are hatched from the eggs, are kept in the apparatus for several days until the yolk-sac is partly absorbed, and they are then transferred to the sea in appropriate apparatus. Experience has shown that the best results are got by liberating the fry before the yolk has been quite used up, and when they are able to feed for themselves.

It is calculated that, taking the two periods together—the time of incubation and the period referred to after hatching—the eggs and larvæ are protected in the apparatus for about half of the time from the spawning of the eggs to the transformation of the post-larval fish, *i.e.* to the adoption of the adult form and habit, after which, owing to the protection afforded by concealment in the sand, the natural mortality is, relatively speaking, small.

In the season of 1904 the floating eggs were first observed in the water of the spawning pond about the middle of January, but they were few in numbers. The first collection was made on the 26th of that month, about the same date, that is, as in the preceding year. The last collection was made on the 29th April, or more than a fortnight earlier than in 1903. This is probably partly accounted for by the greater relative intensity of the spawning in the earlier part of the season in 1904, but it is also, no doubt, connected with the fact that

the number of the adult fishes furnishing eggs, and therefore of the eggs collected, was considerably under what it was in 1903. As pointed out in previous reports, a certain number of the plaice confined in the pond die each year, and this loss is ordinarily made up by a renewed supply of living adult fishes in the autumn, which are obtained from the trawlers employed for scientific purposes in Aberdeen Bay or the Moray Firth, the vessels being provided with large tubs for the collection of the fish, and a constant circulation of water maintained until port is reached. In the autumn and winter of 1903 the same practice was followed, but it was found that large adult plaice, suitable for the hatchery, were exceedingly and unusually scarce, and thus the stock in the pond was only partially replenished.

The total number of eggs collected from the spawning pond throughout the season was 39,600,000, as compared with 65,940,000 in the previous year. Most of them, as is usually the case, were obtained in March, which is the chief spawning month of the plaice. The numbers collected in the various months, and the percentages on the total number, are given in the following table, which also contains for comparison the corresponding monthly percentages for the previous season in 1903:—

		Number of Eggs Collected.	Percentage, 1904.	Percentage, 1903.
January,	-	660,000	1·6	0·3
February,	-	10,320,000	26·1	18·0
March,	- -	22,040,000	55·7	56·2
April,	- -	6,580,000	16·4	24·1
May,	- -	...	..	1·3

It will thus be seen, as above indicated, that spawning was, on the whole, a little earlier in 1904 than in 1903, nearly 28 per cent. of the aggregate number of eggs being collected before March in the former year, as compared with 18 per cent. in the same period in the latter year.

The estimated number of fry which were obtained from the eggs amounted to 34,780,000, and they were liberated in seven lots at various dates in March, April, and May, off Aberdeen Bay, a fishing yawl being employed for the purpose.

Particulars as to the collection of eggs from the pond and the liberation of the fry will be found in the tables which are appended.

The expense of the hatching operations as carried on at the Bay of Nigg is small, compared with the number of fry produced. This is owing to the fact that the hatchery is worked in conjunction with the Marine Laboratory, for which pumping operations are required throughout the year. The annual expenditure that may be ascribed to the hatching work is about £100, the principal items being the maintenance of the apparatus, food for the fishes, and extra coals.

The hatchery was visited by delegations of fishermen sent for instruction by the County Councils of Aberdeenshire and Argyllshire, to whom a series of demonstrations was given.

TABLE I.—Showing the Daily Progress of the Hatching Operations, and the Temperature of the Water, during the Hatching Season 1904.

Date.	Number of Eggs Collected.	Number of Eggs found Dead in Boxes.	Number of Fry put out.	Total Stock in Boxes.	Temperature of Water.	
					Cent.	Fahr.
January 20	...	...	...	...	5.9	42.6
" 21	...	...	...	...	5.2	41.4
" 22	...	...	...	...	6.0	42.8
" 23	...	...	...	...	5.2	41.4
" 24	...	...	...	...	...	...
" 25	...	...	...	...	3.8	38.8
" 26	160,000	...	...	160,000	4.6	40.3
" 27	200,000	...	...	360,000	6.0	42.8
" 28	...	...	...	360,000	5.4	41.7
" 29	300,000	...	...	660,000	...	...
" 30	...	...	...	660,000	5.4	41.7
" 31	...	...	...	660,000	5.6	42.1
February 1	320,000	40,000	...	940,000	5.4	41.7
" 2	300,000	...	...	1,240,000	5.2	41.4
" 3	240,000	120,000	...	1,360,000	4.8	40.6
" 4	...	...	...	1,360,000	4.6	40.3
" 5	400,000	140,000	...	1,620,000	5.0	41.0
" 6	400,000	...	...	2,020,000	4.4	39.9
" 7	...	...	...	2,020,000	...	...
" 8	520,000	...	...	2,540,000	4.6	40.3
" 9	...	...	...	2,540,000	5.2	41.4
" 10	560,000	180,000	...	2,920,000	4.8	40.6
" 11	...	...	...	2,920,000	5.0	41.0
" 12	...	...	...	2,920,000	5.0	41.0
" 13	840,000	...	...	3,760,000	6.1	43.0
" 14	...	...	...	3,760,000	4.8	40.6
" 15	...	...	...	3,760,000	6.0	42.8
" 16	...	200,000	...	3,560,000	5.6	42.1
" 17	1,200,000	...	...	4,760,000	5.3	41.5
" 18	640,000	...	...	5,400,000	...	...
" 19	...	160,000	...	5,240,000	3.2	37.8
" 20	560,000	...	...	5,800,000	4.6	40.3
" 21	...	...	...	5,800,000	4.6	40.3
" 22	760,000	...	...	6,560,000	5.0	41.0
" 23	1,000,000	...	...	7,560,000	5.2	41.4
" 24	840,000	160,000	...	8,240,000	5.0	41.0
" 25	...	...	...	8,240,000	4.8	40.6
" 26	960,000	...	...	9,200,000	4.4	39.9
" 27	...	...	...	9,200,000	4.4	39.9
" 28	780,000	120,000	...	9,860,000	4.6	40.3
" 29	...	...	...	9,860,000	4.2	39.6
March 1	1,120,000	...	...	10,980,000	4.4	39.9
" 2	...	...	...	10,980,000	5.0	41.0
" 3	1,020,000	...	...	12,000,000	5.0	41.0
" 4	...	180,000	...	11,820,000	5.2	41.4
" 5	...	...	...	11,820,000	5.8	42.4
" 6	...	...	...	11,820,000	3.6	38.5
" 7	1,600,000	220,000	...	13,200,000	3.8	38.8
" 8	1,720,000	...	...	14,920,000	4.8	40.6
" 9	1,660,000	...	...	16,580,000	5.0	41.0
" 10	...	...	...	16,580,000	6.4	43.5
" 11	1,200,000	...	...	17,780,000	6.8	44.2
" 12	1,400,000	220,000	...	18,960,000	5.3	41.5
" 13	800,000	...	...	19,760,000	5.4	41.7
" 14	...	...	...	19,760,000	6.2	43.2

TABLE I.—continued.

Date.	Number of Eggs Collected.	Number of Eggs found Dead in Boxes.	Number of Fry put out.	Total Stock in Boxes.	Temperature of Water.	
					Cent.	Fahr.
March 15	880,000	...	4,000,000	16,640,000	6·3	43·3
" 16	...	180,000	...	16,460,000	6·8	44·2
" 17	...	...	...	16,460,000	5·8	42·4
" 18	1,740,000	...	...	18,200,000	7·0	44·6
" 19	840,000	240,000	...	18,800,000	7·2	44·9
" 20	...	...	...	18,800,000	6·8	44·2
" 21	1,060,000	...	...	19,860,000	6·9	44·4
" 22	...	200,000	...	19,660,000	6·8	44·2
" 23	1,600,000	...	...	21,260,000	6·8	44·2
" 24	860,000	140,000	...	21,980,000	...	...
" 25	760,000	160,000	5,000,000	17,580,000	5·8	42·4
" 26	1,100,000	...	...	18,680,000	5·8	42·4
" 27	...	...	...	18,680,000	5·6	42·1
" 28	840,000	300,000	...	19,220,000	5·2	41·4
" 29	1,200,000	...	...	20,420,000	6·0	42·8
" 30	640,000	240,000	...	20,820,000	6·2	43·2
" 31	...	...	...	20,820,000	7·4	45·3
April 1	760,000	...	4,000,000	17,580,000	7·0	44·6
" 2	...	220,000	...	17,360,000	5·8	42·4
" 3	680,000	...	...	18,040,000	...	...
" 4	...	180,000	...	17,860,000	6·2	43·2
" 5	1,000,000	...	...	18,860,000	7·8	46·0
" 6	...	...	...	18,860,000	8·0	46·4
" 7	520,000	220,000	...	19,160,000	8·4	47·1
" 8	480,000	...	4,280,000	15,360,000	8·2	46·8
" 9	680,000	...	...	16,040,000	8·0	46·4
" 10	...	...	...	16,040,000	7·6	45·7
" 11	560,000	300,000	...	16,300,000	7·3	45·1
" 12	...	160,000	...	16,140,000	...	...
" 13	...	...	...	16,140,000	7·4	45·3
" 14	440,000	...	...	16,580,000	7·2	44·9
" 15	...	...	...	16,580,000	7·5	45·5
" 16	...	180,000	6,000,000	10,400,000	7·6	45·7
" 17	...	...	...	10,400,000	8·2	46·8
" 18	840,000	...	...	11,240,000	9·6	49·3
" 19	...	...	...	11,240,000	9·4	48·9
" 20	...	120,000	...	11,120,000	7·8	46·0
" 21	...	...	...	11,120,000	7·8	46·0
" 22	400,000	...	...	11,520,000	7·6	45·7
" 23	...	...	...	11,520,000	7·4	45·3
" 24	200,000	...	...	11,720,000	...	...
" 25	...	160,000	...	11,560,000	8·0	46·4
" 26	...	...	7,000,000	4,560,000	8·6	47·5
" 27	...	...	...	4,560,000	8·0	46·4
" 28	...	...	...	4,560,000	8·9	48·0
" 29	20,000	80,000	...	4,500,000	9·0	48·2
" 30	...	...	...	...	10·0	50·0
May 1	...	...	...	...	...	...
" 2	...	...	...	...	9·8	49·6
" 3	...	...	...	...	9·2	48·6
" 4	...	...	4,500,000	...	9·2	48·6
Totals,	39,600,000	4,820,000	34,780,000			

TABLE II.—Showing particulars in connection with the Distribution of Fry.

Date.	Locality.	Temp. of the Water.	Condition of Weather.	Estimated Number of Fry.
March 15	About $11\frac{1}{2}$ miles off Aberdeen Bay.	C. 5.2	Fine.	4,000,000
" 25	" $21\frac{1}{2}$ " " "	5.0	"	5,000,000
April 1	" $11\frac{1}{2}$ " " "	...	"	4,000,000
" 8	" 2 " " "	5.6	"	4,280,000
" 16	" $11\frac{1}{2}$ " " "	6.0	"	6,000,000
" 26	" $21\frac{1}{2}$ " " "	...	" —	7,000,000
May 7	" $11\frac{1}{2}$ " " "	...	"	4,500,000
				34,780,000

V.—ZONES OF GROWTH IN THE SKELETAL STRUCTURES OF GADIDÆ AND PLEURONECTIDÆ. By J. T. CUNNINGHAM, M.A., F.Z.S. (Plates VII-IX.)

PREVIOUS INVESTIGATIONS.

The primary object of Reibisch's investigations was to ascertain what relations existed between the number of eggs produced by a plaice and its size or age, whether if the number of eggs varied, it depended on the size or on the age of the fish or on both. In describing his method of enumerating the eggs to be shed in the following spawning season, Reibisch shows that he was not acquainted with my own paper on the development of the ovarian egg in Teleostei in general and Pleuronectidæ in particular published in the *Quarterly Journal of Microscopical Science* in 1897. For he explains the opacity of the larger eggs in the ovary in August as due to oil-drops—"durch die Aufnahme einer grossen Zahl kleiner fett tröpfchen zu erklären"—whereas I have shown that in *Pleuronectes* ova there are no oil-drops, but only yolk granules, while in the developing eggs of sole, mackerel, &c., both yolk granules and oil-drops are present and are easily distinguished from one another.

Reibisch found great variations in the number of ripening eggs in plaice, and these numbers could not be brought into correspondence with either the weight or the length of the fish. He then found that the various numbers formed three principal groups, between which few or no numbers were found: thus there were large numbers of fish with eggs from 50,000 to 170,000, or from 220,000 to 270,000, but scarcely any fish whose number of eggs lay between 170,000 and 220,000. It seemed therefore probable that the groups of numbers corresponded to different ages, and Reibisch sought for a method of ascertaining the age of the fish.

He rejects entirely the markings of the scales as indications of the age in the plaice, stating that the lamination of the scale can be used for the purpose in view in the carp, but that this is impossible in the case of the plaice. The reasons he gives are that the presence of an annual lamination (Jahresschichtung) is scarcely to be demonstrated in the simple cycloid scales of the plaice, and further, that in almost all regions of the latter there occurs a transformation of the cycloid to the ctenoid form. But he seems to have misunderstood Hoffbauer's work on the carp, for that author deduces the age, not from the lamellæ, if such exist, but from the varying distance between the concentric lines of the scale, and these also occur in the scales of plaice. I have shown by my observations, described below, that the distinction of the growth of successive years in the scales of the plaice, from the different intervals between the concentric lines, is not impossible. The remarks of Reibisch concerning the transformation of the scales into the ctenoid form in the plaice refers to the Baltic variety on which he worked, in which spinules on the scales are strongly developed, especially in adult males. But this does not affect the anterior embedded part of the scale, and I have not noticed spinules on the scales I have examined. The spinules are developed in adult males in the North Sea, but they are usually confined to limited portions of the

skin, and I have not met with spinulated scales hitherto among those I have examined for indications of age.

Reibisch therefore turned his attention, at Hensen's suggestion, to the otoliths. He describes the appearance of these structures as seen by transmitted light. He states that the first year's deposit consists of a very dark, *i.e.* opaque, nucleus or kernel; this is surrounded by a narrow transparent ring, then follows a broad dark zone, which is again surrounded by a light zone, and this again is bounded by a dark contour. He states that the nucleus and the first clear ring with part of the dark zone are formed during pelagic life, the outer clear zone during the sojourn in shallow water near the coast, while the dark contour is formed only when the fish has migrated into deeper water, about January or February. It will be seen that my results agree closely with those of Reibisch, except in the last point, for I have not noticed that the dark zone of the second year had begun to appear in specimens collected in March and April, and it seems to me that it is formed in summer. Reibisch figures the otolith of a specimen 11.5cm. long taken at the end of February, in which he believes the deposit of the second year had begun and was visible at the anterior and lower side of the otolith. He figures also an otolith from a specimen 16.5cm. long taken at the end of February which similarly shows the beginning of the third year's deposit, and another from a specimen 23.5cm. which shows three complete years and the beginning of the fourth. This specimen was a ripe male taken on the 9th March, and the deposit of the fourth year in the figure is almost as wide in some parts as that of the third. It seems to me difficult to believe that this could have been formed in a few weeks, and more probable that it represents the whole deposit of the previous year, so that the specimen was four years old. It is in cases of this kind that the difficulties of the method arise, and they can only be settled by ascertaining with certainty at what time of the year the boundary line between the annual zones is formed. Reibisch assumes that the new opaque deposit begins in January or February, while my own opinion at present is that it does not commence till much later.

Reibisch concludes from his investigations that sexual maturity occurs always at the end of the third year, and that the reason why the fish are so different in size and weight at this period of life is that they were hatched at different periods of the same season. In my experiments on the rearing of flounders in captivity at Plymouth I also found that the majority began to spawn at the end of their third year, but a few were ripe at two years of age.

Reibisch concludes that the darker layers in the deposit of one year in the otolith corresponds to the lower temperature of the water in which the plaice lives, and the more transparent layers to the warmer temperature. He also states that the excretion of carbonate of lime is weaker in the first half of the year, when the temperature is low. According to his reasoning therefore, the more opaque layers are those in which the proportion of carbonate of lime is least, and these are formed at the time when the lower temperature of the surface penetrates to the deeper water, which is usually from January to March. The annual period indicated by a complete zone in the otolith would, on this view, coincide with the calendar year and commence in January.

My conclusions, from my own observations so far as they have gone, are not in harmony with those of Reibisch on the above points. In the first place, it seems to me probable that the opacity would increase, not diminish, in proportion to the amount of carbonate of lime present: this is certainly the case in bone and calcified cartilage, and it is also the case in the scales, where the radiating and concentric lines *between* the sclerites

are very transparent. Secondly, I have not found that the external layers in the otoliths of plaice killed between November and April were dark opaque layers, but, on the contrary, in otoliths at this period the peripheral layers were of the more transparent kind. Thirdly, the conclusions of Reibisch seem to me to be in contradiction to the facts concerning the first or central region of the otolith, and Reibisch excludes the deposit of the first year from consideration on the ground that during this year the young fish are exposed to very varying conditions of whose influence on the organism we know next to nothing. I fail to see the force of this remark; it seems to me we have as much ground for reasoning about the first year as about any other. Now, though the eggs are produced early in the year, when the water is cold, the young plaice do not complete their metamorphosis until May or June. The first specimens which I received this year from Dr. Fulton were caught at four to eight fathoms on May 10. In these the only part of the otolith formed was the central kernel, and apparently not the whole of that. Therefore, it is evident that the opaque portion of the first year's zone, outside the nucleus, is formed in summer, not in winter, in warm water, not in cold; and the condition of the otolith with only the first year's zone, from fish caught in February or March, equally proves that the more transparent zone is formed in winter, not in summer.

This interpretation might seriously affect the conclusions of Reibisch concerning the age of the fish which he examined, as it seems probable that he has interpreted, in some cases, as the commencement of the fourth year's deposit, a zone which in reality represents a whole year of age. Thus fish which he has taken to be three years old might in reality have lived four years.

Jenkins investigated the determination of age from the otoliths in herring and other Clupeidæ. He finds that in the herring there are layers in the otolith as in the plaice, but with some differences. The central nucleus is always transparent, not opaque; the opaque zones are much broader in proportion than in the plaice, and separated by very narrow transparent zones, which, according to Jenkins, are formed at the beginning of the new year. It would seem more probable that, as in the plaice, these form the end of the year's deposit. Jenkins' paper is illustrated by photographs of the object, in which the different zones are not always very distinct. The structure could, I believe, have been shown more satisfactorily by drawings. Jenkins finds that the herring of the Western Baltic have the following lengths at successive years of age:—

1st year,	.	.	.	.	.	11·3–12·1cm.
2nd „	.	.	.	.	.	15·6–16·4cm.
3rd „	.	.	.	.	.	19·0–19·8cm.
4th „	.	.	.	.	.	21·7–22·5cm.
5th „	.	.	.	.	.	23·7–24·5cm.

Jenkins rejects the conclusion held by nearly all naturalists who have investigated the herring, that two season-races can be distinguished, on the ground that ripe or nearly ripe or spent herrings can be found in the Western Baltic at all times of the year.

He has misunderstood a statement which he quotes from myself, that two spawning periods have undoubtedly been observed in the same neighbourhood, stating that it is in contradiction to Heincke's assertion that herring spawn is never found twice in the year on the same spot. There is really no contradiction. Anyone acquainted with the subject knows that spring or winter spawning herring and summer or autumn spawning herring are captured by fishermen in large numbers in the same

district, for instance, in the Western Baltic, where Jenkins studied, but I have never stated that they use the same spawning grounds.

Jenkins finds that the herring becomes sexually mature in its third year.

2. GENERAL DESCRIPTION OF LINES OF GROWTH.

One of the chief objects of my observations was to test the question how far the lines of growth in the skeletal structures of fishes were trustworthy indications of age, whether the annual increments of growth or deposit could be definitely distinguished and counted in all cases. The most direct and satisfactory basis for the assumption that the age of individual fishes can be ascertained by inspection of lines of growth in certain structures would be an extensive study of such lines in fish whose age was known by direct evidence, but hitherto such study has not been possible to any great extent. All I have been able to do is to ascertain the age of specimens of different sizes as indicated by the lines and zones of growth, and to compare the conclusions so reached with those to be derived from other sources, such as the season in which the specimens were collected, their size, and the evidence available concerning the rate of growth from experiments with fish reared in captivity.

Another object which was in view in the investigation was that of discovering, as far as possible, the mode in which the lines of growth were produced, what differences of structure caused the lines, and what was the relation between the seasonal changes in external conditions and the processes of growth taking place in the structures concerned.

In the plaice successive more or less parallel lines and zones are visible in the otoliths, in the scales, in the coracoid element of the pectoral girdle, which consists of calcified cartilage, and the surfaces of the vertebral centra bounding the conical depressions in their anterior and posterior faces.

The otoliths consist of a number of thin layers deposited one over the other around a common centre. The structure may be described as a concentric stratification, and, apparently, when once deposited a layer undergoes no subsequent change. The otoliths are thin and flat, but one surface is more convex than the other, and this more convex surface is in the natural position within the ear-capsule directed inwards and the flat surface outwards. I find the most convenient way to extract the otoliths is to split the skull with a knife from behind forwards, the ear-capsules being then exposed, as they are not separated from the cranial cavity by bone. The otoliths have a longer and a shorter diameter, and along the direction of the longer diameter there is a groove on the central part of the convex side. They appear to be formed as concretions excreted by the epithelium lining the sacculus of the auditory vesicle.

Examined in water when freshly removed from the skull of the fish, the otolith exhibits both concentric and radiating lines, so that its structure resembles that of a scale, but the mode of formation is different, the otolith being formed externally to the epithelium of the auditory sac, which is derived originally from the epidermis (epiblast), while the scale is formed within the derma (mesoblast). At first sight it might be supposed that the successive deposits were formed only at the edge of the otolith, but by examining a transverse slice of the object cut roughly with a knife, it is seen that each successive layer extends over the whole surface, but is exceedingly thin on the two flat surfaces and thicker at the edge. The structure is such as would be produced if a sphere composed of concentric uniform layers of plastic material were very much

compressed so as to form a flat disc. The thin layers on the two faces being translucent, the surfaces of contact between successive layers are seen as lines approximately parallel to the outer edge. The layers are thin and very numerous, but they are grouped into broader zones by differences of opacity. Each zone is usually distinctly defined from that which succeeds it externally, the line of division being due to a sudden increase in opacity in the layers which form the commencement of the next zone. By transmitted light the more opaque layers appear dark, and the more transparent layers light. All my figures show the appearance of the otoliths by transmitted light, the otoliths being examined in water as transparent objects. When the light is shut off from below and the object seen by reflected light, the appearances are reversed, the opaque regions appearing white and the transparent dark. My observations agree closely with Heincke's description of the structure as seen by reflected light, but I find that examination by transmitted light shows the structure more distinctly. The central area or first zone shows minor subdivisions, but the limits of these are not so distinct as the more external boundaries, and the whole of this central area appears to be formed in the first year of life. It consists of a central very opaque nucleus, followed sometimes first by a transparent zone, then one more opaque, and then a broader more transparent. But these minor zones are not always distinct, while the limit of the whole central area is usually quite definite.

The radiating lines are due to narrow grooves on the surface terminating in notches on the edge, and seem to be formed by folds in the membrane of the auditory vesicle containing the otolith.

The scales of the plaice, like those of the cod, exhibit a number of concentric lines formed by ridges on the outer surface of the scale, but these ridges are very much finer, closer together, and less regular than in the scales of Gadidae. In the anterior embedded portion of the scale the ridges are divided up into short bars by radiating bands which appear transparent by transmitted light, but in the posterior more superficial part of the scale these radiating lines are absent, and the ridges appear as continuous wavy lines. Separate sclerites cannot be distinguished as in the cod, although doubtless the ridges and the radiating lines in the one case correspond to those in the other. Successive zones can usually be distinguished in consequence of the fact that the lines or ridges are closer together in certain zones than in others. A complete zone may be considered to be the result of one year's growth. The summer's growth commences with lines or ridges which are rather far apart, and after a certain distance the lines become more closely crowded; then the next summer's growth is indicated again by lines farther apart (fig. 10, pl. viii.) The transition from the crowded lines to those further apart on the outside is somewhat sudden, so that the commencement of the new summer's growth is often fairly distinct. But in most cases the zones are somewhat difficult to distinguish, and it would be by no means easy to form a confident judgment of the age of the fish by examination of the scales alone. The conclusion drawn from the scales must be confirmed or tested by examination of the otolith.

I have not found any sufficiently distinct lines of growth in the opercular bones, as Heincke states, but such lines are visible in the elements of the pectoral girdle and in the concave faces of the vertebrae. In neither case, however, are such good indications given as in the otolith. I have represented the appearance of a vertebra and of the pectoral elements in figs. 13, 14, pl. viii. The pectoral girdle of the plaice consists of a somewhat thick ossified cleithrum, thicker and less expanded ventrally than that of the cod, and a scapula and coracoid consisting chiefly of calcified cartilage. The coracoid comprises two parts, a thin ossified ventral portion bordered by a

slender curved rod of bone, and a somewhat quadrate dorsal portion of calcified cartilage. The centre of growth is at the junction of the bony rod with the cartilaginous plate, and at intervals there are lines parallel to one another where calcification is more complete, and the cartilage consequently more opaque. The scapula shows similar lines, and they are parallel to the edges where the two elements meet. The basal elements with which the fin rays articulate are represented by a small plate of cartilage with three or four minute points of ossification.

The faces of the vertebrae show by reflected light opaque white bands separated by darker, more transparent lines, and these are probably annual increments of growth, but it is difficult to be sure of counting the complete number, as the more central ones seem always doubtful and indistinct.

In the cod the scales (fig. 15) exhibit concentric and radiating lines as in the plaice, but the radiating lines occur all round the scale, and the concentric lines are much more distinct and farther apart. Careful examination shows that the two systems of lines are due to the fact that the outer surface of the scale is made up of rings of separate elements, which may be conveniently termed sclerites. Each sclerite consists of a flat base with a projecting ridge, the ridges being placed in line with those of the neighbouring sclerites of the same ring. The ridge is situated near the outer border of the sclerite, and the edge of it is turned towards the hilum or focus of the scale, so that there is a depression or concavity on the inner side of the ridge. These sclerites are evidently the structures described by Marett Tims as scalelets in the passages quoted from his paper by J. Stuart Thompson (*Jour. Mar. Biol. Assn.*, No. 1, 1904). He states, however, that each scalelet consists of a basal plate with a minute spine projecting from its upper surface, a description which he has apparently taken from the appearance presented in transverse section, whereas the apparent spine is merely the section of a longitudinal ridge on the sclerite, as I have stated. The ridges on the sclerites are also identical with the rolls or cylinders which cover the surface of the scale, according to Ussow's description.

According to Marett Tims, the scalelets are covered with a delicate epidermis. In my sections I find cell-nuclei both on the upper and lower surface of the scale, and have no doubt that the scale is covered with cells, to whose activity its formation is due. These cells or their nuclei are particularly evident at the edges of the scale, where it increases in extent, and where the new sclerites are successively formed. Nuclei can also be seen in the concavity on the inner side of the ridge of the sclerite, which agrees with Klaatsch's statement "that the cells arrange themselves on the surface of the scale in curved rows, and form always in front of themselves the substance out of which the rolls are made." I find, however, that the new sclerites are formed only at the edge, and that the above description of the cells and "rolls" or ridges applies only to the upper surface of the scale. Fig. 17, pl. ix., shows the appearance of a transverse section of the skin of a cod under a low power. The epidermis is of considerable thickness, and consists of small cells whose boundaries are not distinct in the preparation, but whose nuclei are seen as dots. The lowest layer of nuclei are somewhat elongated in a direction vertical to the lower surface of the epidermis. Beneath this lower layer are seen large oval masses of black pigment, the sections of the chromoblasts. In the middle region of the epidermis are a number of rounded cavities. The specimen from which the preparation was made was preserved with formaline, and I am unable to state whether these cavities exist in the living skin or are the result of the action of the formaline. At the surface of the epidermis are seen two minute somewhat fusiform

bodies composed of elongated cells: these are sense-organs, which in the cod are freely distributed over the surface of the skin, in addition to the special organs of the lateral line. The derma below the epidermis consists of fine fibres having a horizontal direction, with numerous nuclei, and in this occur the scale-pockets containing sections of the scales. Of these, three layers at three different levels are seen in most sections, in consequence of the fact that the scales are imbricated, and overlap one another, so that portions of three different rows of scales are cut by one section vertical to the surface. The relations of the sclerites to the lower homogeneous portion of the scale are shown in the figure, but the cellular investment of the scale is not represented, as it is not sufficiently distinct under a low power.

The ridges on the scales are seen to be farther apart in some regions, more closely crowded in others, so that zones may be distinguished. In other words, the sclerites formed at some periods of the growth of the scale are narrower than at others, so that their ridges are closer together. There is good reason for believing that the narrower sclerites are formed in winter, when the temperature is low. In the cod I find that the end of a year's growth is usually indicated by one or two markedly narrow rings, while the gradual narrowing of the sclerites as this boundary is approached, though it can be made out, is not at first obvious. In these points my observations agree generally with the descriptions and conclusions of Mr. J. Stuart Thompson, who, however, though he studied several species of Gadidæ, did not investigate the cod. In larger and older specimens several annual zones can be distinguished, each terminated by a winter zone, between which and the summer growth there is often a distinct contrast. The distinction however, is not so obvious as in the earlier or inner zones, and it would be very difficult, from the scales alone, to form a decided conclusion as to the age of a cod.

Dr. Heincke has pointed out, in his paper in the Report of the International Investigations, shortly to be published, that lines of growth are more or less distinctly visible in various bones of fishes, while the lines and zones of the otolith have previously been investigated in the plaice and herring. In the cod I have examined the bones of the pectoral girdle, of the operculum, of the skull, and of the vertebral column.

The pectoral girdle differs from that of the plaice in several particulars. The cleithrum (the large superficial bone behind the branchial cavity, formerly known as clavicle) is thinner, and only the scapula is directly attached to the posterior and inner aspect of the cleithrum. There is a long and strong post clavicle. The cleithrum is ossified, but the scapula and coracoid consist of calcified cartilage. There is no scapular foramen. There are four distinct and partially ossified fin-supports, instead of one cartilage, as in the plaice. The form of the parts is shown in fig. 20, pl. ix. I could not satisfactorily make out annual zones in any of these structures. On the thin transparent part of the cleithrum there are sometimes visible some lines parallel to the edge, but they are very indistinct. Also in the coracoid there are slightly opaque lines parallel to the edge, but still less distinct, and no definite conclusions as to the age of the fish can be drawn from them. I am unable, therefore, to agree with Heincke, who states that the age of cod can be determined from the coracoid and scapula.

I have found the bones of the operculum and skull equally unsuitable for the purpose here in view. In the vertebral column of a specimen of some size, parallel lines are distinctly visible in almost every part and on every process, including the walls of the anterior and posterior cavities, the neural spines, and the transverse processes, but I have found it impossible to use them as satisfactory indications of age. On the walls of the conical hollows of the centra numerous concentric lines appear,

lines of greater opacity appearing white by reflected light, and these lines are arranged in bands separated from each other by bands of darker, more transparent bone. Each of these bands may indicate a year's growth, being the summer growth separated from that of the next summer by a band where there is less calcareous matter. But it is difficult to decide exactly how many such annual zones are present. Even when one or two of the outer zones seem distinct, the number of the central earlier zones cannot be distinguished with certainty. One may count three at one time, and at the next attempt there seem to be four or five, and the total number always remains doubtful and uncertain.

The otolith in cod and other Gadidæ is large and opaque, and by examining it as a whole nothing can be ascertained of its internal structure. It is therefore, according to Heincke, useless for the purpose of determination of the age of the fish. I have found, however, that the successive laminae of which it is composed can be seen quite distinctly in transverse slices simply cut from the central region of the otolith with a scalpel. Such slices are, of course, rather thick, and their surfaces are rough and irregular. Nevertheless, when they are placed in water in a watch-glass and examined with a low-power objective, they are sufficiently transparent to show the successive laminae of which the otolith is composed, and the laminae in certain zones being much more opaque than in the zones between these, the whole section is distinctly divided into regions which I believe to indicate the annual increments, and which, therefore, show the age of the fish.

The otolith (*i.e.* the sagitta or largest otolith) of the cod is somewhat elliptical in outline, with rather pointed ends, and two surfaces, one convex and rather smooth, the other concave and more irregular. The convex surface is turned inwards, *i.e.* towards the brain, and somewhat downwards, the concave outwards and upwards. The convex surface is marked by a shallow longitudinal groove, into which fits the ridge of sensory epithelium, called the macula acustica of the sacculus. The edge of the otolith is divided by radial grooves into lobes which are chiefly developed on the concave surface, and the central part of the concave surface projects slightly as a convexity. Fig. 16, pl. viii., shows the appearance by transmitted light of a transverse slice as above described. There is a central opaque nucleus surrounded by successive laminae which are thicker in the parts corresponding to the edges of the otolith than in those corresponding to the surfaces. The nucleus is nearer to the convex surface than to the concave. The nucleus is surrounded by a number of opaque laminae, and these are succeeded by a number of more transparent ones. Then comes another zone of opaque laminae, while the most external are again more transparent. According to my interpretation, the opaque zone represents the deposit of one summer, the transparent that of one winter, so that the two zones together represent the result of one year's growth and indicate one year of age. The fish from which the otolith figured was taken was therefore two years old.

For practical purposes, to determine the age of a number of specimens quickly, I find the best method is to examine a few scales in water, noting the number of winter zones, and the age apparently indicated, and then to extract an otolith by splitting the skull in the median plane, and to cut a transverse slice of the otolith in the manner described above. In this way the conclusions drawn from the scales can be tested and confirmed or modified. It may be asked why I have not prepared thinner and more perfect transverse sections of the otolith by grinding down thick slices. I have tried this method in the plaice, and not found it very successful. The piece to be ground down, after one surface has been ground smooth, must be fixed on a glass slide with Canada balsam in

order to grind the other surface. After the operation the section is opaque from the scratching of the surface, and if it is clarified and mounted in balsam it becomes too transparent, so that the contrast between the opaque and transparent zones is largely lost. I have not yet tried the method for transverse sections of the cod's otolith, but doubt if it would be suitable, and in any case the time required makes it useless for practical purposes.

The following are the details of my observations on specimens of Plaice, Cod, and other species:—

YOUNG PLAICE AND DABS COLLECTED BY SHRIMP-NET IN ABERDEEN
BAY IN MAY 1904.

The plaice in this sample ranged from 5·5 to 8·7cm. in length, and there were very few of them. Unfortunately, they were preserved in formaline, and when I came to examine them I found that the action of this reagent had altered the otoliths so that the lines of growth could not be distinctly seen. Formaline has a decalcifying action, and although in these specimens the otoliths were not destroyed, they were rendered quite opaque and granular, so that the usual structure was scarcely visible. It seemed probable, however, that they had the characters of the central deposit of the first year, without any sharp dividing lines separating distinct zones. In this case there can be little doubt that the fish were one year old, as the new brood of the current year are still, in May, in the pelagic stage, and it is unlikely that fish so small should be more than one year old.

The scales are apparently not affected by the formaline as the otoliths are; that is to say the characteristic concentric lines are quite distinct. The posterior or embedded part of the scale consists of five radiating rows of short curved lines, not regularly parallel but irregular, separated by plain bands, while the anterior part of the scale is marked by continuous successive lines approximately parallel to the edge of the scale (fig. 1). There is no division of these series of lines into zones, and the whole may be regarded as the growth of one year.

YOUNG PLAICE FROM SOLWAY FIRTH, COLLECTED ABOUT APRIL 17, 1905.

The results of examination of the otoliths in these specimens are as follows, males and females being given separately:—

MALES, IMMATURE.

(1) 6·6cm. in length.—Only one central area visible. It contains a central opaque nucleus, the part around which is slightly more opaque than the external zone. Concentric lines of lamination faint (fig. 4).

(2) 6·9cm. in length.—Only one central area.

(3) 7·1cm. in length.—Only central area, concentric lines of lamination around the opaque nucleus.

(4) 7·1cm. in length.—Central area only as in other cases, but near the outer edge a distinct transparent band with an opaque band outside it at the extreme edge. This might possibly be the commencement of the second year's deposit.

(5) 9·8cm.—Only one zone.

(6) 9·9cm.—Two zones.

(7) 10·5cm. in length.—Two distinct zones, that is to say a distinct zone outside the central area. The central area is ·95mm. in the shorter diameter, the total transverse diameter of the otolith being 1·92mm.

(8) 10·8cm.—Two zones quite distinct.

(9) 13·2cm.—Shows three zones.

FEMALES, IMMATURE.

(1) 8·9cm. in length.—Only central area present.

(2) 9·2cm. in length.—Otolith shows two distinct zones, the external one being defined by a sharp boundary line, and commencing with several laminae of very opaque deposit (fig. 8, pl. vii.).

(3) 10·5cm. in length.—Two zones visible, the central area small and not quite so sharply defined as usual—12·0cm.

(4) 15·5cm. in length.—Two zones rather less distinct than usual, central area showing distinct lamination.

(5) 15·9cm.—Shows three distinct zones.

According to these results, therefore, males from 6·6cm. to 9·8cm. in length are one year old, and at 10·5cm., or $4\frac{1}{5}$ inches, are two years old. Females may be one year old up to 8·9cm., or very nearly 4 inches, while others from 9·2cm. to 15·5cm., or 4 to 6 inches, are two years old, and one of 15·9cm., or about $6\frac{2}{5}$ inches, is three years old.

According to Heincke, in the Report of the International Committee, vol. iii., the plaice at the Sylt are from 10cm. or less to 14cm. at one year of age, 10cm. to 19cm. at two years, and 13cm. to 28cm. at three years. These sizes are taken from specimens collected in March, and therefore comparable with those from the Solway Firth examined by me. The results therefore agree, but Heincke's observations have the defect that males and females are not distinguished in them.

SPECIMENS OF PLAICE RECEIVED FROM ABERDEEN ON MAY 8, 1905, AND CAUGHT A FEW DAYS BEFORE.

These specimens, of which 14 were carefully examined, ranged in length from 4·8cm. to 11·4cm., and only one was identified as a female. The others were either male or their sex could not be determined. They must be considered as belonging to last year's brood, as the young plaice of the current year have but just completed their metamorphosis.

(1) 4·8cm. long.—Sex not determined. One zone only in otolith, transparent ring next to the nucleus not seen. One year old.

(2) 4·8cm. long.—Sex not determined. One zone only in otolith; but there was a narrow, more transparent zone next to the nucleus, as in Reibisch's description of the first year's growth. One year old.

(3) 5cm. long.—Apparently male. One annual zone only in otolith, a broad region of somewhat opaque layers round the central nucleus, more transparent narrower zone at outer edge, that is the transparent region next to the nucleus as described by Reibisch, was not visible. Concentric single layers distinct in the middle zone.

(4) 5·7cm., probably male.—One zone in otolith.

(5) 5·7cm., probably male.—One zone in otolith.

(6) 6·7cm., female.—One zone only.

(7) 7·2cm., probably male.—One zone only.

(8-10).—Three specimens, 8·5cm. long, apparently male, all showing one zone only.

(11) 9·6cm., male.—One zone only.

(12) 9·8cm., male.—One zone only.

(13) 10·3cm., male.—One zone only.

(14) 11·4cm., male.—One zone only.

PLAICE RECEIVED FROM ABERDEEN, APRIL 1, 1905, AND COLLECTED
JUST BEFORE THAT DATE.

MALE.

(1) *15.1cm., immature.*—Otolith shows two zones, the third of the current year may have begun, but shows no distinct contrast with the second zone. The scales also show two zones, but not so easily distinguished.

FEMALES.

(1) *12cm. long, immature.*—Only one zone, or central area; fish, therefore, one year old (fig. 9, pl. vii.).

(2) *14cm., immature.*—Otolith shows only one undivided area, may be considered one year old. Scales also show no division into zones.

(3) *15cm., immature.*—Two distinct zones in otolith, outer zone sharply defined from central region, indicating two years' growth.

(4) *15cm., immature.*—Two distinct zones in otolith; the central region is much smaller than the whole otolith of (2), and does not show distinct lamination as that does. The calcified cartilage of the coracoid also shows two zones, but the boundary line is rather faint.

(5) *16.7cm., immature.*—Otolith with central region and one outer zone separated by distinct boundary line. On the outer border there are a few opaque layers, which may be the commencement of this year's deposit, but they are not defined by a distinct boundary from the second zone.

(6) *20.7cm., immature.*—Otolith shows four distinct zones. It seems difficult to believe that this fish, not quite $8\frac{1}{2}$ inches long, and quite immature, should be really four years old, in which case it would be at least five years of age before it spawned for the first time.

(7) *Plaice, 22.9cm., immature.*—Only one distinct boundary, with very dark and opaque layers outside it. Several fainter lines in the central area, but these I regard as all occurring in the first year's growth.

With the exception of (1), (2), and (6), therefore, all these specimens were two years old and at the commencement of their third year.

LARGER PLAICE, CAUGHT 21 MILES S.S.E. OF ABERDEEN, ABOUT
MARCH 8, 1905.

MALE.

(1) *26.7cm., immature.*—Testes a mere narrow band along the anterior interspinous bone at posterior border of body cavity. Otolith shows three complete zones, with no distinct indication of the beginning of the fourth. May be taken to be three years old.

FEMALES.

(1) *29cm. long, immature.*—Five distinct zones in otolith. It would appear, therefore, that this fish would be at the end of its sixth year when it began to spawn.

(2) *34.7cm., immature.*—Ovary very small, without yolked eggs. Four complete zones in otolith, last one scarcely as wide as the others, but still too wide to be considered the deposit of the season now commencing.

(3) *37.5cm., immature.*—Otolith shows five distinct zones, including, of course, the central area. The fish, therefore, five years old. The fifth zone is not quite so wide as the fourth. In the scales also five zones can be distinguished, but not so certainly or clearly as in the otoliths.

In the coracoid four complete zones are visible, and an outer fifth, which is narrower. In the sub- and inter-operculum I can make out no distinct zones or boundary lines.

(4) 50cm. (about 1 ft. 8 in.) *mature, with ripe ovaries*.—In the right otolith six complete zones visible and a peripheral seventh. I was in some doubt whether this last was the seventh annual growth in progress, or whether it was really complete in the preceding winter and the eighth about to commence. The latter view seems more probable, so that this fish is seven years old. As it is far beyond the limit of size for immature plaice, it may have spawned either once or several times previously.

The zones in the scales were rather difficult to distinguish, but there were apparently seven, including the central region and the extreme external zone. In the coracoid also there were visible six complete zones and a seventh at the periphery. The latter was narrower than the others, and opaque, like the commencement of a year's growth. At present I do not know when the new growth commences, but in examining other specimens subsequently I have assumed that the outermost zone in specimens collected in March and April represents the last complete year, and not the commencement of the new annual growth.

HEADS AND PECTORAL REGIONS OF PLAICE SENT FROM ABERDEEN, 16TH DECEMBER 1904: SEX NOT STATED.

(1) 26.2cm. ($10\frac{1}{2}$ inches actual measurement).—Otolith shows three zones, that is to say central area, complete second zone, and external zone. The fish is therefore in its third year; the third year would be completed some time in the commencement of next year.

(2) 31.2cm. ($12\frac{1}{2}$ inches actual measurement).—Otolith shows same condition, indicating that the fish is in its third year. If I understand him aright, this would be placed by Heincke in the second group, plaice which have lived two complete years and are in their third. In this case, the fish is larger than the maximum for this age of plaice on the Sylt grounds off the German coast (fig. 12).

(3) 35cm. (14 inches actual measurement).—Otolith shows four complete zones, and a fifth at the margin. Same number could be made out in the scales, in the coracoid, and in the conical hollow on the faces of the vertebrae (pl. viii., fig. 11 otolith, fig. 10 scale).

(4) 37.5cm. (15 inches actual measurement).—The otolith shows seven zones, including both the central area and peripheral zone. According to this, the fish was in its seventh year (pl. vii., fig. 5). The first three zones are strongly separated, but the fourth and sixth boundary lines were much less distinct, and it seemed possible that they might be accidental and not annual lines. In this case, however, the fourth and fifth zones would be of disproportionate width, so that it seems more probable that the fish is really in its seventh year and not in its fifth.

(5) 46.8cm. ($18\frac{3}{4}$ inches actual measurement).—The otolith shows five zones, including the peripheral one. In this specimen I examined the hollow of the vertebral centra and the coracoid, and have figured them (fig. 14). In these also five zones can be distinguished, though the central area of the vertebral surface is scarcely visible, that is to say it is difficult to make out its boundary line.

I also examined a large plaice 50.5cm. long, bought at a fishmonger's in London last autumn. The otolith showed six zones. The fish was a mature female, and was therefore in its sixth year.

COD FROM ABERDEEN, CAUGHT OCTOBER 1900.

Length of fish 8.6cm. ($3\frac{2}{5}$ inches). Length of scale from side of body .94mm., breadth .46mm. Number of concentric lines on scale 10 or 11. No winter zone. Age six or seven months.

SPECIMENS OF COD FROM ABERDEEN, CAUGHT NOVEMBER 10, 1904.

Of the following four specimens only parts of the skin and pectoral girdle were examined, so that only the scales give indications of age.

(1) *Length of fish 47.0cm. (1 ft. 6 $\frac{1}{2}$ in.), ♀, immature.*—Length of scale 2.4mm. Two winter zones distinguished. Within the first winter zone 9 or 10 rings, from first to second 19 or 20, outside the second 6 or 7. Age inferred two years and about six months. The rings in this and other cases are counted on the posterior part of the scale, as they do not all seem to extend round the whole scale.

(2) *Length of fish 5.4cm. (1 ft. 9 $\frac{3}{8}$ in.), ♂, immature.*—Number of lines in first annual zone 9 or 10, in second 13, in third 10, beyond 9. Probable age three years six months. I was not quite certain in this case about the number of winter zones in the outer part of the scale; the total number of complete annual zones may have been two or three, but three seemed more probable.

(3) *Length of fish 6.4cm. (2 ft. 1 $\frac{3}{8}$ in.), ♀, immature.*—First zone 10 lines, second 12 to 14 lines, third 12 lines, outside 8 or 9. Some doubt as in previous specimens. Age of fish three years six months, or possibly two years six months.

(4) *Length of fish 7.3cm. (2 ft. 5 $\frac{1}{8}$ in.).*—♂ with large testes but not ripe, probably mature. First zone 10 lines, second 12 to 15, third 12 to 15, beyond 4 or 5. Probable age three years six months.

SPECIMENS OF COD CAUGHT AT ABERDEEN ABOUT MARCH 9.

(1) *Length of fish 24.3cm. (10 in.).*—Otolith shows two annual zones. Scale also shows two zones; number of rings in first 13 or 14. Age inferred two years.

(2) *Length of fish 30.5cm. (12 $\frac{1}{5}$ in.).*—Both scales and otolith indicate two annual zones. Inferred age two years.

(3) *Length of fish 30.7cm. (12 $\frac{1}{4}$ in.).*—In the scales a single winter boundary zone is quite evident. It is also evident that the ridges are close together at the edge of the scale, showing that the winter growth was nearly or quite finished when the fish was killed. Inferred age two years. A transverse section of the otolith also showed two annual zones (pl. viii., fig. 16).

(4) *Length of fish 33.5cm. (13 $\frac{3}{8}$ in.).*—In scales one complete annual zone and another outside it. It seemed as if the two or three outermost rings belonged to the commencement of the new summer's growth, but I was not sure of this. Number of rings in first annual zone 14–15, in second 16, beyond 3. Transverse section of otolith also showed two complete annual zones. Both in scales and otoliths a slight interruption was visible in the first summer's growth, but this did not seem to be a definite winter zone. Such an interruption might occur probably enough occasionally from unfavourable conditions. Age inferred two years.

The following specimens of cod were obtained at the same time, and the heads were sent to me, with labels indicating the size and condition of the fish:—

(1) *Length of fish 44.3cm. (17 $\frac{3}{4}$ in.), 1 $\frac{3}{4}$ lbs. weight.*—♀ with small ovary, probably immature. Otolith in transverse section shows three annual zones. Inferred age three years.

(2) *Length of fish 45.6cm. ($18\frac{1}{4}$ in.), $2\frac{1}{4}$ lbs. weight.*—Scales behind head show two winter zones besides the external edge, in other words three annual zones. First zone 12 rings, second 17 to 19, third about 13. Otolith also shows three annual zones quite distinctly. Inferred age three years.

(3) *Length of fish 67.5cm. (2 ft. 3 in.), $8\frac{1}{2}$ lbs. weight.*—♂ with small ovary, apparently immature. Scale from pectoral region shows three winter zones besides the outer edge, in other words four annual zones complete. The first zone contains 14 rings, the second 20, the third 16, the last only 7. It might be supposed that the last zone was only the commencement of the present season's growth, or, on the other hand, the fourth winter zone might not be complete, as the water is still cold in March. I thought it most probable that the fish was four complete years old. In the transverse section of the otolith four complete zones were visible. In this specimen I examined the pectoral girdle and the concave faces of the vertebrae. In the coracoid I could with difficulty make out three boundary lines in addition to the outer edge, but they were very indistinct, and would be untrustworthy without the other indications. In the hollows of the vertebrae there were numerous concentric lines, but the boundaries of annual zones were not distinct.

According to these latter results, the cod at two years of age is 10 to 13 or 14 inches in length, at three years 17 to 19 inches, at four years 27 inches; but of course it would require the examination of a large number of specimens to ascertain the average and range of sizes at these ages.

SPECIMENS OF COD FROM EXPERIMENTS DESCRIBED BY DR. FULTON IN
TWENTY-SECOND REPORT OF THE BOARD (FOR 1903).

In the last Report Dr. Fulton, in his paper on "The Rate of Growth of Fishes," described certain experiments on the influence of temperature on the growth of cod and other fishes, experiments which were carried out in tanks in the Board's Marine Laboratory at Aberdeen. Several of the specimens which formed the subjects of these experiments were sent to me by Dr. Fulton, and I have examined them with the following results. Some of the specimens were from Tank I., in which the water was of the natural temperature, not artificially heated. Dr. Fulton does not give any dates in connection with these experiments, but I presume that the codling were put into the tank in the autumn of 1903. They were then from 12cm. to 15cm. long, or six inches and less. It is not certain, but seems most probable, that they were then in their first year. They were killed on August 4, 1904, and then sent to me.

(1) *Cod, Tank I., 20.4cm. long.*—The otolith in transverse section shows two annual zones, *i.e.* a central opaque region, then a zone of more transparent laminae, then a zone of opaque laminae again. The transparent zone corresponds to the previous winter, and the specimen supports the view that the opaque laminae are deposited in summer, as they extended almost to the edge, showing that they were being formed when the fish was killed in August. The specimens were preserved in formaline, and the skull bones were rather soft, but the layers of the otolith were not obscured. In the scales also a winter zone was visible, the ninth to twelfth rings being narrower and closer together.

(2) *24.8cm.*—In this also I made out two annual zones in the otolith, though the winter zone was not quite so transparent. In the scales the winter zone included rings 15 to 21 and was quite distinct, beyond it were only seven or eight rings.

These specimens, therefore, were in their second summer, according to

the structural indications, and this conclusion seems to be in accordance with the actual age.

Whiting from Tank I., 24.8cm. long.—Otolith shows one complete year and commencement of second, *i.e.* dark central region, then transparent zone, then dark external zone. The scales also show a distinct winter zone; there are 14 summer lines, then 12 winter lines, ending in a very distinct boundary of one or two very narrow rings; outside this boundary the new summer growth shows only seven or eight rings. Evidently the growth of the year is not very large even at the beginning of August. These whiting were 14cm. to 20cm. long when put into the tank, and it might be thought that they must then have been in their second year, but the structural indications are that the fish were only in their second year when killed.

Cod from Tank No. 4, length 36.6cm.; killed November 5, 1904.—I only received one specimen from this tank, which was kept artificially warm during the winter 1903–04. This, however, had not prevented the appearance of the boundaries between the annual zones of growth, for the transverse slice of the otolith distinctly showed two annual zones, and showed also a transparent zone externally in addition to the layers seen in the specimen killed in August. The scales also showed one winter zone at rings 15 to 20, and outside this 19 rings. To anyone who refers to Dr. Fulton's paper this will not seem surprising, for his tables show that, in spite of the artificial increase of temperature in the tank in winter, the cod grew nearly twice as fast in the last 55 days of the experiment than in the first 100. The growth was therefore slower in the winter, and the reduction of growth is shown by the winter zone in otolith and scales.

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DESCRIPTION OF PLATES.

PLATE VII.

- Fig. 1. Scale of Plaice, 8.7cm. long, caught near Aberdeen, May 1904. Zeiss a_2 Oc.3 camera.
- Fig. 2. Otolith of Plaice, 5.6cm. long, hatched in the spring of 1903, reared in small tank, and killed Nov. 5, 1904. Zeiss a_2 Oc.2.
- Fig. 3. Scale of same specimen, actual length .29mm. Zeiss A Oc.3.
- Fig. 4. Otolith of Plaice, 6.6cm. long, ♂, from Solway Firth, caught April 1905.
- Fig. 5. Otolith of Plaice, 37.5cm. (15 inches) long. Zeiss a_2 Oc.2. Shows seven zones, indicating apparently seven years of age.
- Fig. 6. Otolith of Plaice, 12.2cm. long, from Solway Firth, caught April 1905. Zeiss a_2 Oc.2 camera. Shows two annual zones.
- Fig. 7. Otolith of Plaice, 22.9cm. long, caught near Aberdeen, April 1, 1905. Zeiss a_2 Oc.2 camera.
- Fig. 8. Otolith of Plaice, 9.2cm. long, ♀ immature, from Solway Firth, April 1905. Zeiss a_2 Oc.2 camera.

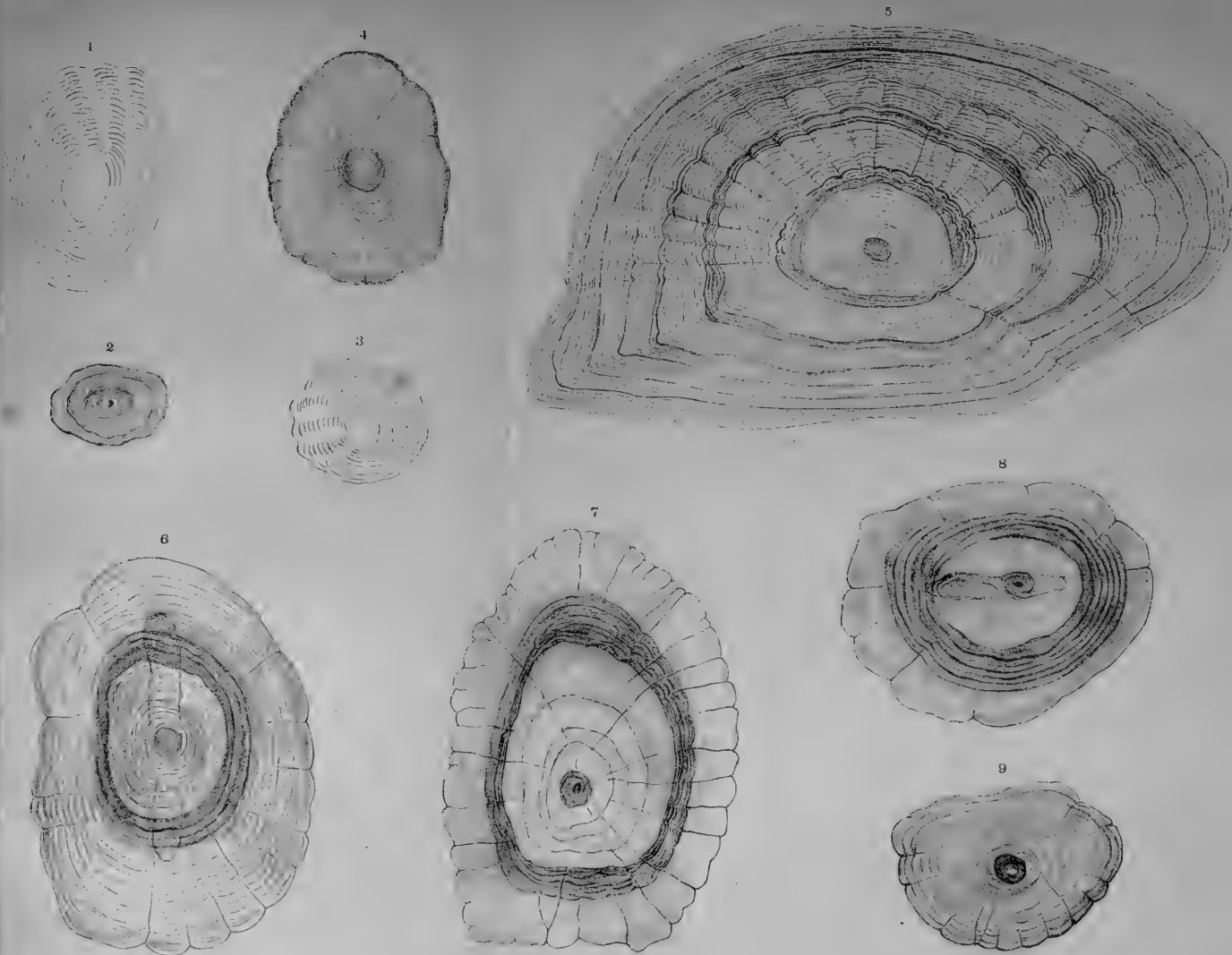
- Fig. 9. Otolith of Plaice, 12cm. long, ♀ immature, caught near Aberdeen, April 1, 1905. Shows only one year's growth.

PLATE VIII.

- Fig. 10. Scale of Plaice, 35cm. long (14 inches), from Aberdeen. Zeiss A Oc.2. Shows five annual zones of growth.
 Fig. 11. Otolith of same specimen. Zeiss a₂ Oc.2. Shows also five zones of growth, with slight irregularity in fourth zone.
 Fig. 12. Otolith of Plaice, 31.2cm. long (12½ inches), from Aberdeen. Shows three annual zones.
 Fig. 13. One of the anterior vertebrae of Plaice, 18¾ inches long, from Aberdeen, showing the zones of growth in the concave face of the vertebra.
 Fig. 14. Coracoid and scapula of same specimen, showing five zones of growth.
 Fig. 15. Scale of Cod from Dr. Fulton's experiments, killed August 1904, in its second year. Zeiss A Oc.2 camera. Shows two annual zones.
 Fig. 16. Cod, 30.7cm. long, caught near Aberdeen, March 1905. Transverse section of otolith, showing two annual zones of growth.

PLATE IX.

- Fig. 17. Transverse section of skin of Cod from Dr. Fulton's experiments. Preserved with formaline. Zeiss A Oc.3.
 Fig. 18. Portion of same section under higher power, to show nuclei on upper and lower surfaces of scale, and at edge.
 Fig. 19. Surface view of scale of Whiting under higher power, showing nuclei on upper surface and their relation to the ridges of the sclerites.
 Fig. 20. Pectoral girdle of Cod. *Cl.* = Cleithrum (clavicle). *Co.* = Coracoid. *S.* = Scapula.



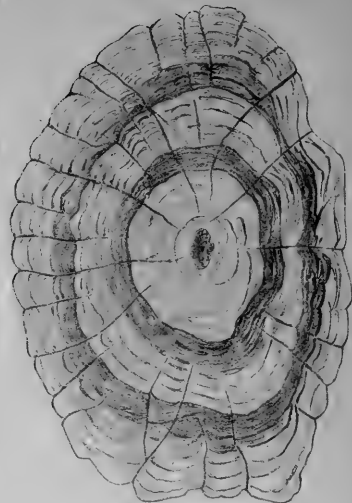
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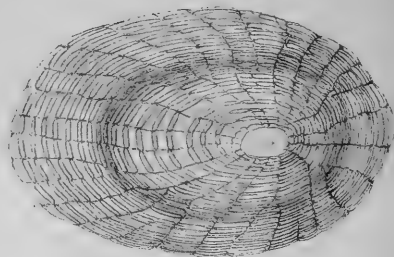
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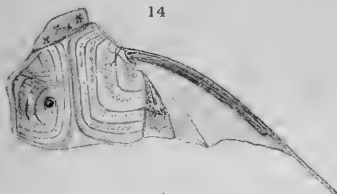
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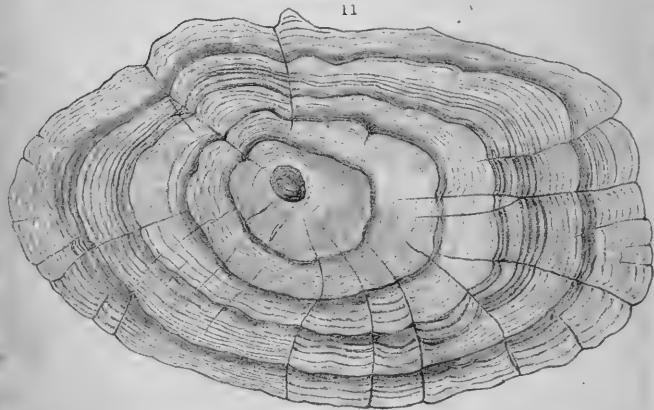
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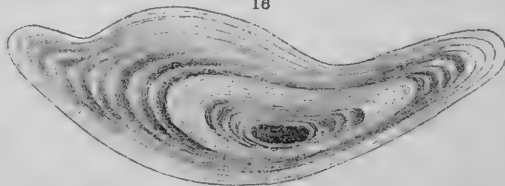
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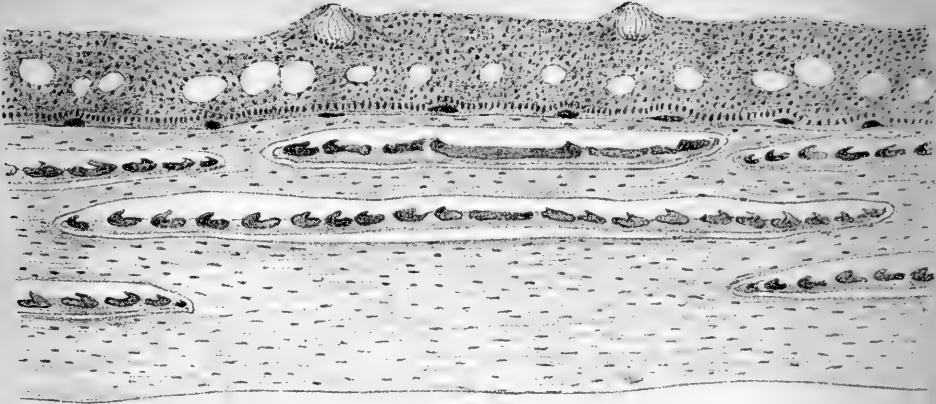


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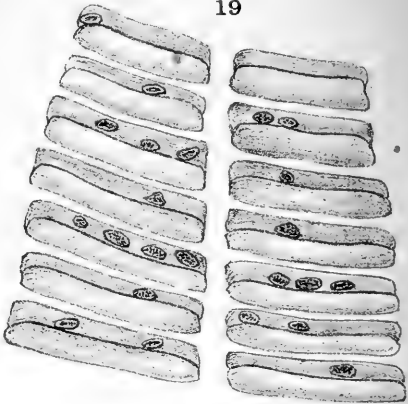
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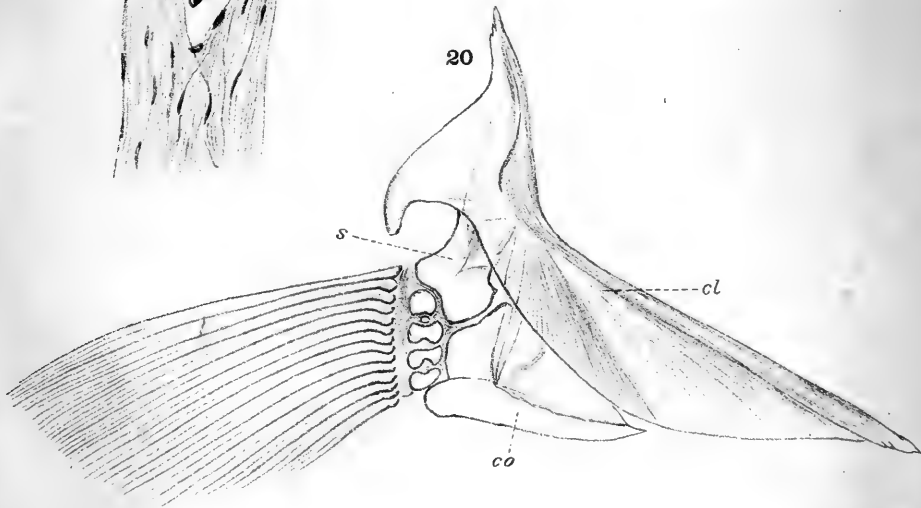
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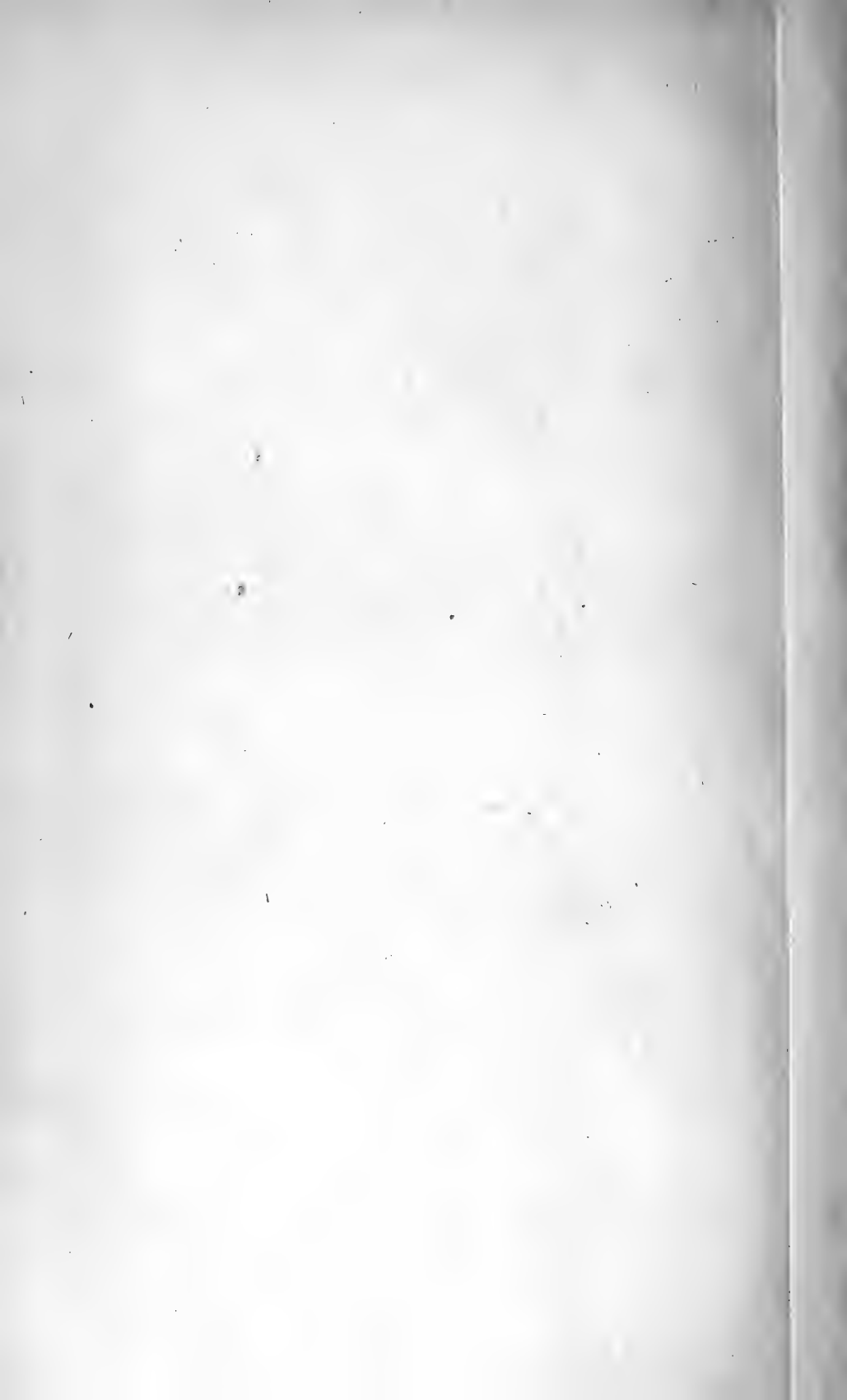


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VI.—ON SOME NEW AND RARE CRUSTACEA FROM THE SCOTTISH SEAS.

BY THOMAS SCOTT, LL.D., F.L.S., ETC.

(Plates X.—XIII.)

PRELIMINARY NOTE.

The Crustacea mentioned in the following notes were obtained for the most part in collections made during various Fishery investigations carried out under the direction of Dr. T. Wemyss Fulton, Scientific Superintendent of the Fishery Board for Scotland.

Several of the forms described appear to be new to science, others have not before been recorded from the Scottish seas, and one or two belong to a curious parasitic group of minute Copepoda found usually in the marsupium of Crustacean species belonging to the Amphipoda, Sympoda, and others of the smaller Malacostraca.

The following are the species described :—

Pseudocyclopia giesbrechti, Wolfenden—male described for the first time.

Euryte longicauda, Philippi, var. minor—new variety.

Longipedia coronata, Claus—new to Scottish fauna.

Stenhelia pygmæa, Norman and Scott—new to Scottish fauna.

Ameira elegans, sp. n.

Laophonte longiremis, sp. n.

Cletodes sarsi, sp. n.

Dyspontius curticaudatus, sp. n.

Sphaeronella aore, sp. n.

„ *vararensis*, sp. n.

„ *minuta*.

„ „ var.

„ sp. from *Hemilamprops rosea*.

Arcturella dilatata—now first recorded from the Forth estuary.

DESCRIPTION OF THE SPECIES.

SUB-ORDER CALANOIDA.

FAM. PSEUDOCYCLOPIIDÆ.

Genus *Pseudocyclopia*, T. Scott (1892).*

Pseudocyclopia Giesbrechti, Wolfenden. Pl. x., figs. 1–9.

1902. *Pseudocyclopia Giesbrechti*, Wolfenden, Journ. Mar. Biol. Assoc., Plymouth, vol. vi., No. 3, January, 1902, p. 370, pl. iv.

* *The Tenth Annual Report of the Fishery Board for Scotland, III.*, p. 246 (1892).

The female of this species was described and figured by Dr. Wolfenden in the Journal of the Marine Biological Association for January, 1902, but the male appeared to be unknown.

The male specimen (fig. 1), which I now propose to describe, agrees so closely with Dr. Wolfenden's definition and figures of the female that, after making allowance for sexual differences, I have no hesitation in ascribing it to the same species.

The cephalothorax is robust, and appears to be composed of only four segments, but the fifth is so small as to be almost entirely obscured by the fourth; the abdomen is slender and much shorter than the body; rostrum not much produced. The length of the specimen figured is about .8mm. (about $\frac{1}{31}$ of an inch).

Antennules (fig. 1) moderately slender, except towards the proximal end; they are shorter than the cephalothoracic segment, and composed of seventeen joints; the basal joint is large and stout and rather more than half as long as the entire length of the remaining joints, which are all short—the tenth, fourteenth, fifteenth and last are, however, rather longer than any of the other twelve. The formula shows approximately the proportional lengths of all the joints:—

Proportional lengths of the joints,	58	5	6	4	3	4	4	7	7	9	6	6	7	9	12	8	10	
Numbers of the joints, -	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Posterior antennæ, outer ramus scarcely so long as the inner one, and composed of five joints—the third and fourth joints are very small and sparingly setiferous (fig. 3).^{*} Mouth appendages similar to those of the other described species.

All the four pairs of swimming feet (figs. 4–7) are also similar to those of the other described species, except that they are rather more hispid, but especially the inner branches of the fourth pair, and the outer branches also to some extent. In this pair the joints are more or less covered with minute prickles, as shown in the drawing (fig. 7), and the same character distinguishes the fourth pair in the female described and figured by Dr. Wolfenden.

Fifth pair are elongated and unequal on the two sides; the left leg is long and slender, for though the first and second joints are short, the other is of considerable length, and is probably longer than the drawing shows it, as the extremity is apparently slightly damaged; a dense fringe of small delicate hairs extends along part of the proximal half of the inner margin of the slender end joint, and terminates distally at a small hook-like process (fig. 8). The right leg is considerably dilated at the proximal end of the second joint, but becomes attenuated towards the distal extremity; the third joint is narrow, and terminates interiorly in one or two finger-like processes; while the end joint, which is very slender, and tapers gradually to a pointed apex, is furnished with a small process exteriorly near the proximal end, as shown in the drawing (fig. 8.). The abdomen is composed of five moderately short segments, and the furcal joints are also short (fig. 9).

Habitat.—Firth of Forth, west of Queensferry. Dredged Nov. 17, 1893, but only now described and figured.

Remarks.—One of the characters peculiar to the genus *Pseudocyclopia* is the presence of a long, moderately stout spine which springs from the inner distal angle of the first basal joint of the third pair of legs and reaches to about the end of the inner branch, as shown in figure 6.

^{*} Dr. Wolfenden describes the posterior antennæ as one-branched, but the outer ramus so characteristic of the *Pseudocyclopiidæ* as of the other *Calanoida* had probably become accidentally detached, and had thus given to the posterior antennæ an appearance somewhat unique among *Calanoids*.

SUB-ORDER CYCLOPOIDA.

FAM. CYCLOPIDÆ.

Genus *Euryte*, Philippi (1843).

Euryte longicauda, Philippi, var. *minor*. Pl. x., figs. 13 and 14.

Euryte longicauda is a moderately common species, and has already been recorded from the Firth of Forth and other places. Two forms, a smaller and a larger, have occasionally been observed, but they appear to differ very little from each other except in size. Figures 10 and 13 on plate x. show a female of the usual size and one of the small variety. The first measures about 1.2mm. and the other .8mm. in length; the drawings of them are similarly enlarged. But though they differ so distinctly in size, there appears to be scarcely any structural difference between them: for convenience sake, however, the small form might be distinguished as var. *minor*. The fifth foot in this variety is slightly different in shape and armature from that of the other, as shown by figures 12 and 14. Both of the forms represented here are from South Bay, Firth of Forth.

SUB-ORDER HARPACTICOIDA.

FAM. LONGIPEDIIDÆ.

Genus *Longipedia* (1863).

Longipedia coronata, Claus. Pl. x., figs 15-17.

Prof. G. O. Sars has shown that the *Longipedia* usually recorded from Scottish waters as *Longipedia coronata*, Claus, was not the species described by him under that name, but another and quite distinct form to which he has given the new name of *Longipedia Scotti*.* The true *L. coronata*, Claus, appears to be moderately rare in our seas, and is probably limited to moderately deep water. I have only observed it in two gatherings, and they were on each occasion collected in over fifty fathoms. *Longipedia coronata*, Claus, which is scarcely so large as *L. Scotti* shows several minute points of difference from the other species, i.e., the arrangement of the three prominent setæ on the long end-joint of the inner branches of the second pair of legs in the female is similar to that of *L. minor*, Scott, but there are short stout spine-like processes at the distal end of the basal joints of the outer and inner branches (fig. 15). The fifth pair of feet, though similar to those of *L. Scotti*, are slightly different in form and armature (fig. 16); while the last segment of the abdomen bears two short stout spines on each side of the prominent medium spine on the posterior dorsal margin (fig. 17).

Habitat.—Moray Firth, off Fraserburgh, September 29, 1904, collected by Dr. H. C. Williamson, to whom I am indebted for the specimens. The same species was also obtained in one of the "Gold-seeker" gatherings, and is recorded in the Bulletin of the Council of the International Bureau for November, 1904.

* Sars' Crustacea of Norway, vol. v., p. 11, pl. v., fig. 1 (1904).

FAM. STENHELIIDÆ.

Genus *Stenhelis*, Boeck (1864).*Stenhelis pygmaea*, Norman and Scott.1905. *Stenhelis pygmaea*, N. and S., Ann. and Mag. Nat. His. (7), vol. xv., p. 284.

This small species has recently been noticed in a gathering of Crustacea collected at Station II., Firth of Forth, on December 26, 1894.* It was described by Norman and Scott from a specimen dredged near Eddystone Lighthouse by Rev. Canon A. M. Norman.†

S. pygmaea is one of the smaller species belonging to this genus, and measures only about $\frac{1}{16}$ of an inch in length; it appears to differ from other described species by the peculiar structure of the antennules and of the first pair of swimming feet, and by the form and armature of the fifth pair.

Genus *Ameira*, Boeck (1864).*Ameira elegans*, sp. n. Pl. x., figs. 18 and 19; pl. xi., figs. 1–9.

Description of the Female.—The body, which is moderately elongated and slender, has a general resemblance to *Canthocamptus palustris*, but it is rather less robust and somewhat smaller; the specimen figured measured only .7mm. (nearly $\frac{1}{38}$ of an inch) in length (pl. xi., fig. 1).

Antennules moderately elongated, eight-jointed, and sparingly setiferous; the second joint is considerably longer, and the fifth and seventh smaller than the others (pl. xi., fig. 2). The formula shows the lengths:—

Proportionate length of the joints,	13	23	14	15	9	10	7	11
Number of the joints, - - -	1	2	3	4	5	6	7	8

The antennæ (posterior antennæ) are moderately large, and are each furnished with a small uniarticulate outer ramus bearing a few apical setæ (pl. xi., fig. 3).

Mandibles narrow, oblong, masticatory end obliquely truncated, and armed with small teeth; mandible palp small, the basal part furnished with two setæ at the extremity—one being stout and spiniform, and one plumose—and a small uniarticulate branch bearing a few setæ is articulated to the distal half of the basal part (pl. xi., fig. 4).

The second maxillipeds are stout, and armed with a moderately long terminal claw (pl. x., fig. 18).

The swimming feet resemble those of *Canthocamptus palustris*, but differ in a few minor particulars, as shown by the drawings. In the first pair, which are moderately stout, the first joint of the inner branches reaches to slightly beyond the end of the outer branch, the next two joints are short, but the end joint is rather longer than the other; in the outer branches the middle joint, which is slightly longer than the first or third has a small spine on the inner distal angle; all the three joints have the usual marginal spines—one on each of the first and second joints, and three spines and two setæ on the lower half of the outer margin and end of the third joint (pl. xi., fig. 5).

In the second, third, and fourth pairs the inner branches are all shorter than the outer. The middle joint of the second pair bears a single setæ on the inner distal angle; but the end joint, which is rather longer than

* This gathering was only partially examined at the time it was collected, and it has not even yet been exhaustively dealt with.

† Cf. Ann. and Mag. Nat. Hist. for March, 1905, p. 284.

the other two, is provided with two setæ on the inner margin, two spines on the outer margin, and also with two long spines of unequal length and a long seta at the apex; the inner branches have the outer edge of each joint fringed with minute bristles, and a moderately long seta springs from the distal angles of the first and second joints and from the lower half of the third joint; the third joint is also armed with a terminal spine and two long terminal setæ (pl. xi., fig. 6).

The armature of third and fourth pairs is similar to that of the second, except that there are two setæ instead of one on the lower half of the inner margin of the last joint of the inner branches (pl. x., fig. 19, and pl. xi., fig. 7).

The fifth pair resembles, to some extent, the same appendages in female specimens of *Canthocamptus palustris*, but the inner portion of the primary joints, which are broadly sub-triangular, have the apex more or less distinctly truncated rather than rounded. The armature of the inner portion of the primary joints consists of five apical setæ, of which the three inner ones and the outermost are only of moderate length, but the other—the second from the outside—is greatly elongated. The secondary joints are oblong, with the outer and inner margins nearly parallel, the length being equal to about twice the width at the broadest part; outer margin nearly straight, inner slightly convex, apex obliquely truncate and furnished with six setæ; the second from the inside is very long, while the second from the outside is short; the others are of varying lengths, as shown in the drawing (pl. xi., fig. 8). Furcal joints very short (pl. xi., fig. 9).

Habitat.—West of Dunbar, near low water, collected by hand-net October 16, 1894, as well as in a collection from Musselburgh collected the same year; rare.

Remarks.—Though this species resembles *Canthocamptus palustris* in some respects, the difference in the proportional lengths of the joints of the antennules and of the outer and inner branches of the first pair of swimming feet, and also in the form of the fifth pair, and especially of the secondary joints of that pair, is sufficient to distinguish it.

FAM. LAOPHONTIDÆ.

Genus *Laophonte*, Philippi (1840).

Laophonte longiremis, sp. n. Pl. xi., figs. 10–20.

Description of the Female.—Body slender, and somewhat similar to *Laophonte thoracica* in general appearance. The cephalothoracic segment is equal in length to the next three taken together, gibbous on the under side, the ventral margins boldly rounded, the depth being nearly equal to the length of the segment; the remaining segment short. Furcal joints about equal in length to the last abdominal segment. Length of the specimen represented by the drawing (fig. 10) .6mm. (about $\frac{1}{42}$ of an inch).

Antennules long, slender, and composed of seven joints (fig. 11); first and second joints subequal, considerably longer than the first, the next three small, but the end joint is nearly as long as the combined lengths of the three preceding joints, as shown in the formulæ:—

Proportional lengths of the joints, -	16	25	22	7	4	7	16
Number of the joints, -	1	2	3	4	5	6	7

A long, slender, sensory filament springs from the upper distal angle of the fourth joint, as shown in the drawing.

The posterior antennæ are moderately slender and elongated, and the end joint is armed with a hook-like process on the outer distal angle in addition to the usual terminal setæ (fig. 12); outer ramus small, uniarticulate, and provided with two marginal and two terminal setæ.

Mandibles small and armed with a few bluntly-rounded teeth on the biting edge; palp small and furnished with a minute uniarticulated branch (fig. 13).

Maxillæ and first maxillipeds as in *L. thoracica*.

Second maxillipeds also similar to those of that species, the terminal claw being long and slender (fig. 14).

In the first pair of natatory legs the inner branch has the joint slender and nearly twice the length of the entire outer branch, and it bears a few minute bristles on the inner margin; the end joint is small and armed with a moderately stout and elongated claw. The outer branches are composed of three subequal joints, but the last is rather smaller than either of the other two (fig. 15). Outer branches of the second, third, and fourth pairs all three-jointed, elongated, and slender, and bearing long slender spiniform marginal setæ and very long terminal bristles, as shown by the drawing (figs. 16-18); inner branches short, two-jointed, and scarcely reaching to the second joint of the outer branches; first joint considerably shorter than the second, and each furnished with a single seta near the end of the inner margin; the end joint of the inner branches of the second and fourth pairs has a single seta on the lower half of the outer margin, two on the inner margin, and two at the apex; but in the third pair there are three setæ on the inner margin of the end joint of the inner branches.

Moreover, a single seta springs from near the middle of the inner margin of the end joint of the outer branches of the second pair, and two from the inner margins of the same joints of the third and fourth, but otherwise the armature of the outer branches of the second, third, and fourth pairs is much alike.

Fifth pair of moderate size, primary joint broadly oblong; the inner distal angle slightly produced, and furnished with three setæ on the inner margin—one being near the middle and two near the distal end; the produced part bears one seta also on its inner margin and three others of small size and unequal length at its apex. The primary joint also carries a slender spiniform seta on the outer distal angle; the secondary joint is narrow and elongated, the length being equal to fully four times the width at the broadest part; it is provided with about four setæ on the outer margin, one on the inner margin, and one on the produced and narrow apex (fig. 19).

Habitat.—In an old quarry at Granton, Firth of Forth, which is open to the sea; collected August 25, 1894; rare. This species differs from any other known to me; no male has yet been observed.

FAM. CLETODEIDÆ.

Genus *Cletodes*, Brady (1872).

Cletodes Sarsi,* sp. n. Pl. xii., figs. 1-9.

Description of the Female.—This species is somewhat intermediate between *Cletodes neglecta* and *C. longicaudata*, but differs from *C. neglecta* in having longer furcal joints, and from *C. longicaudata* in the furcal joints of that species being still more elongated (fig. 1). The length of the specimen figured is about .5mm. ($\frac{1}{30}$ of an inch).

* Named in compliment to Herr Professor G. O. Sars, the eminent Norwegian carcinologist.

The antennules (fig. 2) are very short, and composed of five joints; the length of the second joint is about equal to that of the last, but the penultimate joint is very small, as shown by the formula:—

$$\begin{array}{rcl} \text{Proportional lengths of the joints,} & - & 5 \cdot 13 \cdot 9 \cdot 2 \cdot 13 \\ \text{Number of the joints,} & - & 1 \quad 2 \quad 3 \quad 4 \quad 5 \end{array}$$

The posterior antennæ are of moderate size, the end joint has the inner margin fringed with minute bristles, while two short setæ spring from the distal half of the same margin; the outer rami is very small and unarticulate, and furnished with two or three setæ (fig. 3).

The mandible, maxillæ, and first maxillipeds are similar to those of *C. neglecta*. The second maxillipeds are very small, the end joint has the inner margin fringed with fine bristles and bears a long and very slender claw (fig. 4).

All the four pairs of swimming feet are moderately short, and are somewhat similar to each other in structure; the outer branches are three-jointed and bear moderately long, slender spines or setæ; the end joints of the outer branches of the first and second pairs are each provided with four terminal setæ, but the third and fourth pairs have five setæ round the end of the last joint; these joints of the third and fourth pairs also differ from those of the first and second in that they become gradually and distinctly broader towards the distal extremity, as shown in the drawing (figs. 7 and 8); the inner branches are all two-jointed, short, and narrow; the first joint is very small, but the second is elongated; the inner branches in the first pair scarcely reach beyond the end of the second joint of the outer branches, while in each of the second, third, and fourth pairs the inner branches are slightly shorter than those of the preceding pair; the inner branches of the first and second pairs are each furnished with two, and the others with three, terminal setæ (figs. 5–8).

The fifth pair are small; the primary joint, which is very short, is produced interiorly into a narrow plate, which becomes somewhat wider towards the distal end, and is furnished with a short and moderately elongated spine, which is articulated to a notch near the middle of the inner margin, and also with a stout and moderately long spine and an elongate seta on the truncate apex; the secondary joint is long and very narrow; a short seta springs from near the middle and another from near the distal end of the outer margin. Moreover, a moderately long and spini-form seta springs from near the distal end of the inner margin of the secondary joint, and there is also a slender apical seta (fig. 9).

The furcal joints are rather longer than the combined lengths of the last two abdominal segments, and they each bear a small bristle on the upper half of the outer margin and another on their dorsal aspect.

Habitat.—Firth of Forth, 1901; rare.

FAM. HARPACTICIDÆ.

Genus *Harpacticus*.

Harpacticus uniremis, Kröyer. Pl. x., fig. 20.

This species, which is so fully described and figured by Professor G. O. Sars in the new volume of his *Crustacea of Norway* now in course of publication, has been observed in one or two places round the Scottish and English coasts—I have even obtained it in material washed from the filters in use at the hatchery at the Bay of Nigg.

In this species the limbs are strongly hispid, and it is otherwise quite distinct from the other described species belonging to the genus found on

our shores. Figure 20 in plate x. shows one of the fifth pair of thoracic feet of a female specimen.

FAM. ASTEROCHERIDÆ.

Genus *Dyspontius*, Thorell (1859).

Dyspontius curticaudatus, sp. n. Pl. xiii., figs. 1-10.

Description of the Female.—Length .8mm. (about $\frac{1}{31}$ of an inch); somewhat similar to *Dyspontius striatus* in general appearance, but considerably smaller, except that the abdomen is also distinctly shorter, and the cephalosome rather more distinctly triangular in front. The abdomen and furcal joints are very short, and are together scarcely longer than the combined lengths of the preceding segments of the metasome (fig. 1).

The antennules are short, moderately stout, sparingly setiferous, and composed of eight joints; second and last joints subequal and longer than any of the others; the fourth is short, being only about half the length of the joint on either side, as shown in the annexed formula:—

Proportional lengths of the joints,	14	·	25	-	10	·	5	·	10	·	8	·	10	·	23
Numbers of the joints, -	-	-	-	1	2	3	4	5	6	7	8				

A short sensory filament springs from about the middle of the end joint (fig. 2).

The antennæ (posterior antennæ) are moderately elongated, four-jointed, and armed with three moderately stout terminal spines, the middle one being considerably elongated and the outer very small; the outer ramus is rudimentary (fig. 3). The siphon reaches to about the end of the cephalosome.

The mandibles are very slender, and a small portion of the distal end of the inner margin is coarsely dentate, as shown in the drawing (fig. 4).

The maxillæ are somewhat similar to those of *Dyspontius striatus*, but are rather stouter, and the inner ramus is proportionally scarcely so elongate, being only slightly longer than the outer ramus; the terminal setæ of the outer and inner rami are also similar to those of that species (fig. 5).

The first maxillipeds resemble those of *Dyspontius fringella*, Giesb., very closely; they are furnished with a small fringe of setæ near the end of the second joint; the terminal claw is moderately short (fig. 6).

The second maxillipeds have the second joint elongated, but the third and fourth, which are subequal in length, are together not much more than half the length of the second joint; the terminal claw is stout and moderately short, and about equal to the combined lengths of the two preceding joints (fig. 7).

The swimming feet resemble those of *Dyspontius striatus*. In the first pair neither of the two branches bear terminal spines; the first joint of the outer branch, which is nearly twice as long as the next, carries a short seta on the distal angle of the outer margin, and another on the lower half of the inner margin; the second joint bears a short spine on the outer angle and a seta on the inner margin, while the last joint is furnished with two small spines on the outer margin, two setæ on the inner margin and two more setæ at the apex; the first joint of the inner branches bears one and the second two setæ on their inner margin, while the third carries three on the inner margin, one small seta on the outer margin, and two of moderate length at the apex, as shown in the drawing (fig. 8); the second pair, which were somewhat similar to the third, were damaged and no

drawing is given of them. In both branches of the third pair the armature of the first and second joints resembles that of the same joints in the first pair, but in the third joint of the outer branches there are three short spines on the outer margin, five setæ on the inner margin, besides a moderately stout terminal spine; while that of the third joint of the inner branches has three setæ on the inner margin, a small seta on the outer margin, and a stout spine with a seta in front of it at the apex (fig. 9).

In the fourth pair the outer branches only are developed, and resemble the outer branches of the third pair; the inner branches are represented by a minute digitiform process (fig. 10).

The fifth pair very minute.

Habitat.—Dredged in the vicinity of Culross, a few miles above Queensferry, Firth of Forth.

This form is in some respects similar to *Dyspontius striatus*, but it differs in having only eight-jointed antennules and in the abdomen being very short. The male is unknown.

FAM. NICOTHOIDÆ.

Genus *Nicothö*, Aud. and M. Edw., 1826.

Nicothö astaci, Audouin and M. Edwards.

1826. *Nicothö astaci*, Aud. and M. Edw., Ann. Sci. Nat., 1st ser., vol. ix., p. 345, taf. 49, figs. 1-9.

Dr. H. C. Williamson, while examining a lobster sent to him from Dunbar, observed this curious parasite adhering to one of the gills and kindly handed it over to me. This is the first specimen of *Nicothö* I have seen from the Forth district. The distribution of this species, so far as concerns the British Islands, appears to be coextensive with its host.

FAM. CHONISTOMATIDÆ.

Genus *Sphaeronella*, Salensky (1868).

Sphaeronella minuta, T. Scott. Pl. xii., fig. 18; pl. xiii., fig. 16.

This small form—parasitic on the Amphipod *Periocolodes longimanus* (Spence Bate)—was described in Part III. of the Twenty-second Annual Report of the Fishery Board for Scotland, published in 1904 (pl. xv., figs. 11-15). One or two more specimens of *Periocolodes* infested with the same species of *Sphaeronella* were recently observed in gatherings of small Crustacea collected in the Moray Firth by Dr. H. C. Williamson, to whom I am indebted for the specimens. Figure 18, plate xii., shows a *Periocolodes* with a parasite *in situ*, and figure 16, plate xiii., shows an enlarged drawing of an adult female bearing two ovisacs, each of which is about as large as the parasite itself.

Sphaeronella minuta, var. *valida*. Pl. xiii., fig. 17-20.

This form, which was obtained in the marsupium of an amphipod, *Melamphopus cornutus*, Norman, resembles *Sphaeronella minuta* so closely except in size, that I can only regard it as a large variety of that species. The female, which is represented by the drawing (fig. 17, pl. xiii.), measures 73mm. in length, or about one and a half times the size of *S. minuta*. The body is globular in form and the appendages, so far as

they could be made out, appeared to be closely similar to the corresponding appendages in *S. minuta*. No males have yet been observed. The Amphipod was obtained in a gathering of small Crustacea collected off the east side of Inchkeith, Firth of Forth, in May, 1901.

Sphaeronella aore, sp. n. Pl. xii., figs. 10-17.

Female moderately large; its outline, when seen from above, had an obscurely quadrate appearance and was about as long as broad; the head forms a small rounded protuberance in front; length .86mm. (about $\frac{1}{30}$ of an inch); ovisacs large (fig. 10).

Antennules apparently four-jointed, but the end joint is very small; the penultimate joint, which is equal to about one and a half times the length of the one that precedes it, is furnished with a number of short setae (fig. 12).

The first maxillipeds are uniarticulate, very robust, and armed with a stout terminal claw (fig. 14).

The second maxillipeds are moderately stout, elongated, and four-jointed; the second joint is as long as the third and fourth combined, while the third is narrower than the second and rather longer than the ultimate joint; terminal claw short and stout (fig. 15).

The male, which measures about .28mm. has a somewhat close resemblance to the male of *Sphaeronella chinensis*, H. J. H.* The cephalo-thoracic plate is widest posteriorly where the breadth is about equal to the length; the sides, which are nearly straight, converge towards the proximal end, which is trilobed, the median lobe being larger than that on either side, abruptly truncate in front and produced slightly beyond the lateral lobes, which are bluntly rounded. Posterior portion of the body short, semicircular in outline, and covered with short bristles (fig. 11).

The antennules of the male differ slightly from those of the female; they are rather shorter and stouter (fig. 13).

The second maxillipeds differ considerably from those of the female; the second joint is moderately stout, but comparatively shorter than in the second maxillipeds of the female, and furnished with two or three transverse rows of short bristles; the two end joints are slender, the ultimate one being very small and bearing a moderately stout claw (fig. 16).

The thoracic legs appear to be uniarticulate and armed with one long and one short terminal seta (fig. 17).

Habitat.—In the marsupium of *Aora gracila* (Bate), from a townet gathering collected in the Dornoch Firth by Dr. H. C. Williamson, which he kindly handed over to me for examination.

Sphaeronella vararensis, sp. n. Pl. xiii., figs. 12-15.

This *Sphaeronella* was found in the marsupium of an Amphipod, *Megaluropus agilis*, Norman, captured in Burghead Bay, Moray Firth, by Dr. H. C. Williamson, on Dec. 12, 1904, and kindly handed over to me along with some other interesting things. One or two females of this parasite were observed, but no males. The females are of an ovate form, widest in the middle, and nearly one and a half times longer than broad; head somewhat produced and broadly truncate in front. The specimen represented by the drawing measured .53mm. (about $\frac{1}{17}$ of an inch) and carried two ovisacs, each nearly as long as the parasite itself; the ovisacs were ovate in form, broadly rounded on the outer, but flattened on the

* The "Choniostomatidæ," by H. J. Hansen, pp. 106 and 112, Pl. II. and Pl. III.

inner aspect (fig. 12). The female as seen from the side is moderately and evenly rounded on the dorsal aspect and somewhat flattened below, as shown in figure 13.

The antennules appear to be four-jointed, but the end joint is very small, while the penultimate joint is nearly as long as the preceding two joints taken together (fig. 14).

The second maxillipeds are moderately large and composed of four joints; the first and second joints are robust, and the second is considerably more elongate than the next two joints combined, which are short and narrow, and furnished with a short terminal claw (fig. 15). This form does not agree with any species known to me. No males were observed.

(?) *Sphaeronella* sp. from a *Hemilamprops rosea* (Norman).

A moderately large *Sphaeronella*, bright red in colour, was quite recently obtained in the marsupium of a specimen of *Hemilamprops rosea* (Norm.) captured in Loch Fyne by Dr. Williamson. So far as I am aware no *Choniostomaton* has yet been recorded from this species of the Lampropidae.

ISOPODA VALVIFERA.

FAM. ARCTURIDÆ.

Genus *Arcturella*, G. O. Sars, 1897.

Arcturella dilatata, G. O. Sars. Pl. xiii., fig. 11.

1897. *Arcturella dilatata*, G. O. Sars, Crustacea of Norway, vol. ii., p. 92, pl. xxxviii.

A male specimen of this species was obtained in some material dredged off St. Monans on May 22, 1901. The species appears to be widely distributed, but moderately rare. The late Dr. Robertson has recorded this species from the Firth of Clyde, and I have observed one or two specimens in gatherings dredged off Fair Island in October, 1900.

DESCRIPTION OF THE PLATES.

PLATE X.

Pseudocyclopia giesbrechti, Wolfenden.

	Diam.
Fig. 1. Male, side view	× 90.
Fig. 2. Antennule	× 260.
Fig. 3. Antenna	× 260.
Fig. 4. Foot of first pair	× 260.
Fig. 5. Foot of second pair	× 260.
Fig. 6. Foot of third pair	× 260.
Fig. 7. Foot of fourth pair	× 260.
Fig. 8. Foot of fifth pair	× 260.
Fig. 9. Abdomen and furcal joints	× 195.

Euryte longicauda, Philippi.

Fig. 10. Female, dorsal view	× 90.
Fig. 11. Antennule	× 195.
Fig. 12. Foot of fifth pair	× 390.

Euryte longicauda, var. *minor*.

Fig. 13. Female, dorsal view	.	.	.	.	.	.	×	90.
Fig. 14. Foot of fifth pair	.	.	.	.	.	.	×	390.

Longipedia coronata, Claus.

Fig. 15. Foot of second pair, female	.	.	.	.	.	.	×	90.
Fig. 16. Foot of fifth pair, female	.	.	.	.	.	.		enlarged.
Fig. 17. Last segment of abdomen and furcal joints	.	.	.	.	.	.	×	195.

Ameira elegans, sp. n.

Fig. 18. Second maxilliped, female	.	.	.	.	.	.	×	780.
Fig. 19. Foot of third pair	×	260.

Harpacticus uniremis, Kröyer.

Fig. 20. Foot of fifth pair		enlarged.
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PLATE XI.

Ameira elegans, sp. n.

Fig. 1. Female, side view	×	60.
Fig. 2. Antennule	×	260.
Fig. 3. Antenna	×	390.
Fig. 4. Mandible	.	.	.	.	.	.	×	780.
Fig. 5. Foot of first pair	.	.	.	.	.	.	×	260.
Fig. 6. Foot of second pair	.	.	.	.	.	.	×	260.
Fig. 7. Foot of fourth pair	.	.	.	.	.	.	×	195.
Fig. 8. Foot of fifth pair	.	.	.	.	.	.	×	390.
Fig. 9. Last segment of abdomen and furcal joints	.	.	.	.	.	.	×	195.

Laophonte longiremis, sp. n.

Fig. 10. Female, side view	.	.	.	.	.	.	×	135.
Fig. 11. Antennule	.	.	.	.	.	.	×	520.
Fig. 12. Antenna	.	.	.	.	.	.	×	520.
Fig. 13. Mandible	.	.	.	.	.	.	×	780.
Fig. 14. Second Maxilliped	.	.	.	.	.	.	×	780.
Fig. 15. Foot of first pair	.	.	.	.	.	.	×	300.
Fig. 16. Foot of second pair	.	.	.	.	.	.	×	260.
Fig. 17. Foot of third pair	.	.	.	.	.	.	×	260.
Fig. 18. Foot of fourth pair	.	.	.	.	.	.	×	260.
Fig. 19. Foot of fifth pair	.	.	.	.	.	.	×	390.
Fig. 20. Last segment of abdomen and furcal joint	.	.	.	.	.	.	×	195.

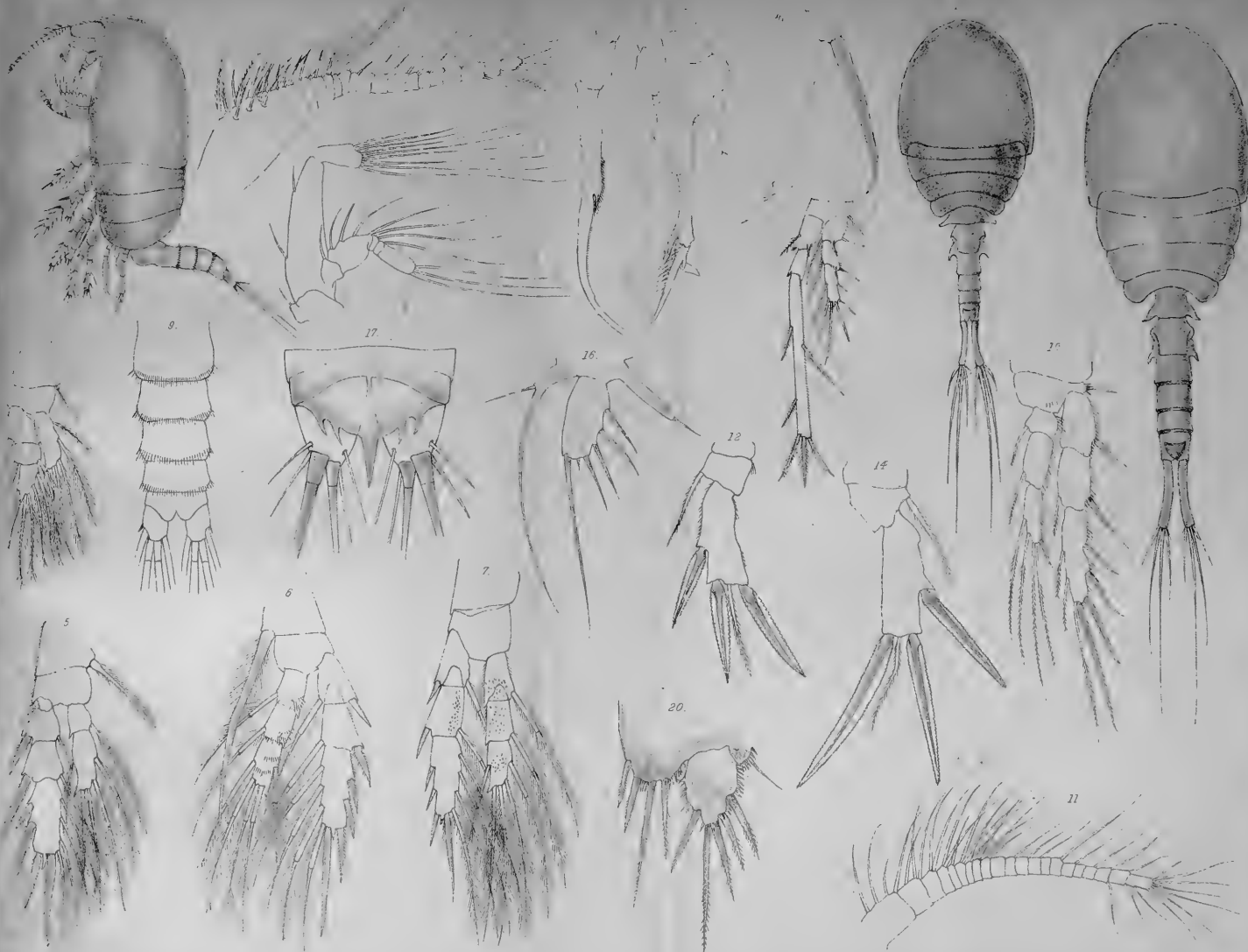
PLATE XII.

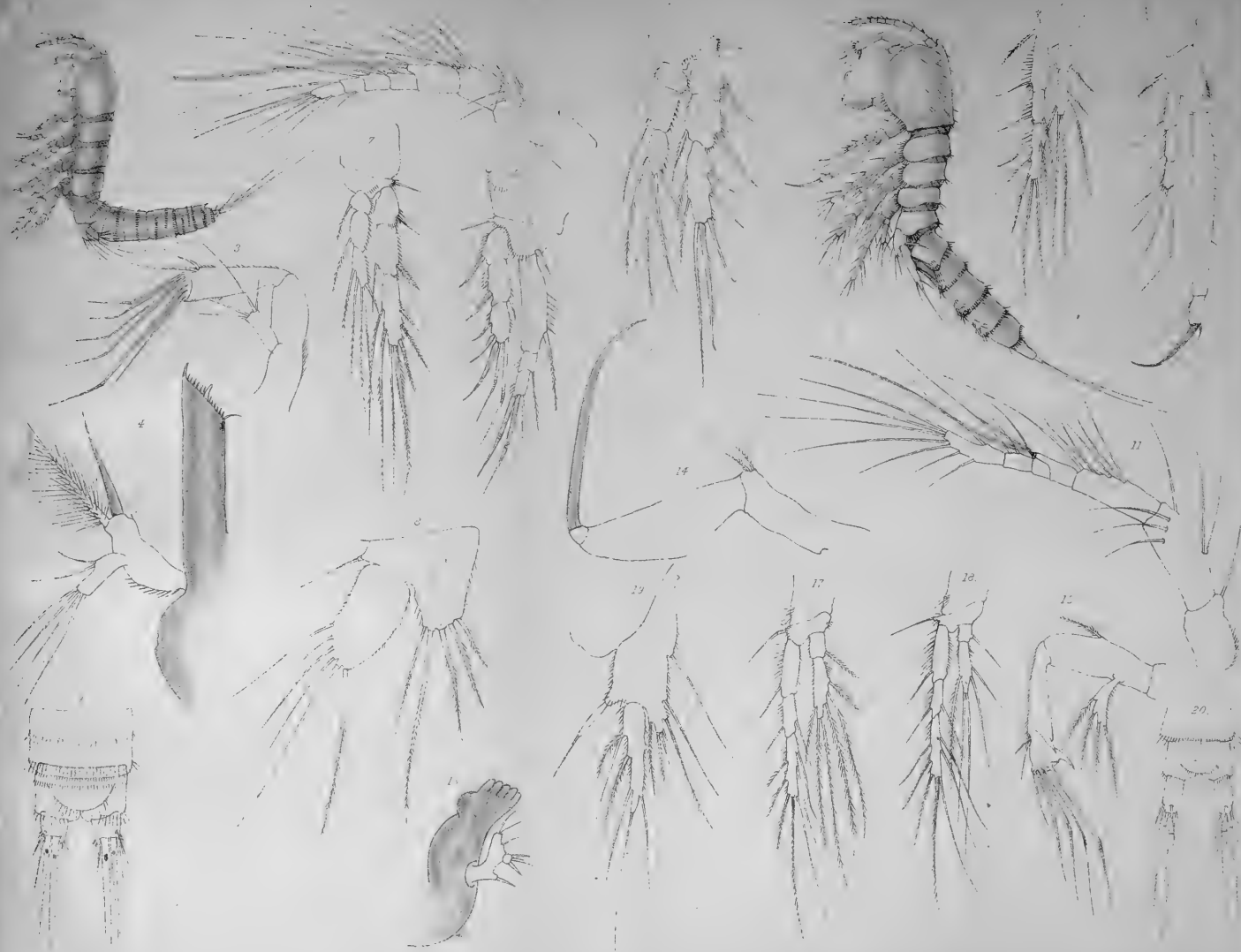
Cletodes Sarsi, sp. n.

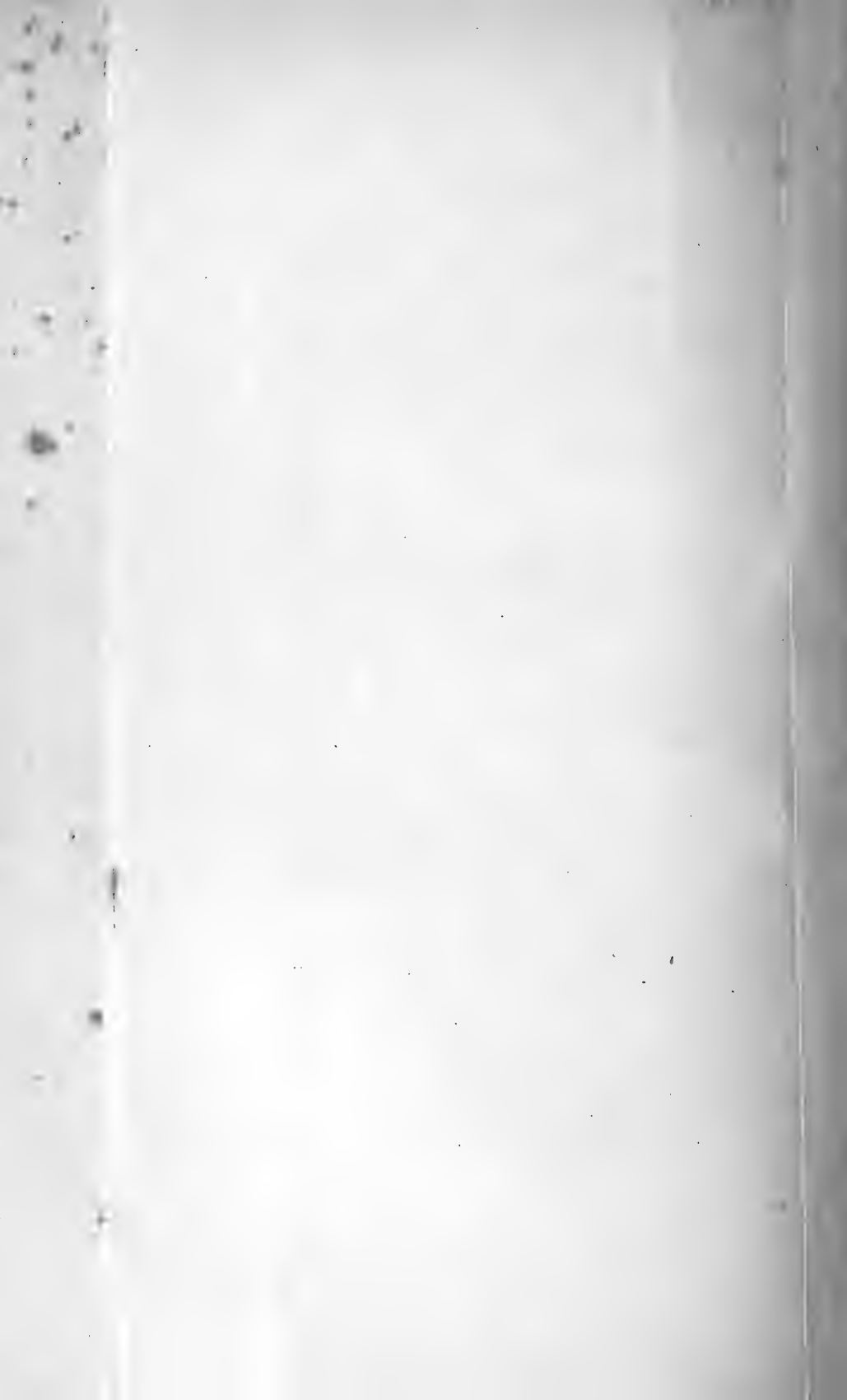
Fig. 1. Female, dorsal view	.	.	.	.	.	.	×	180.
Fig. 2. Antennule	.	.	.	.	.	.	×	780.
Fig. 3. Antenna	.	.	.	.	.	.	×	780.
Fig. 4. Second maxilliped	.	.	.	.	.	.	×	780.
Fig. 5. Foot of first pair	.	.	.	.	.	.	×	780.
Fig. 6. Foot of second pair	.	.	.	.	.	.	×	780.
Fig. 7. Foot of third pair	.	.	.	.	.	.	×	780.
Fig. 8. Foot of fourth pair	.	.	.	.	.	.	×	780.
Fig. 9. Foot of fifth pair	.	.	.	.	.	.	×	780.

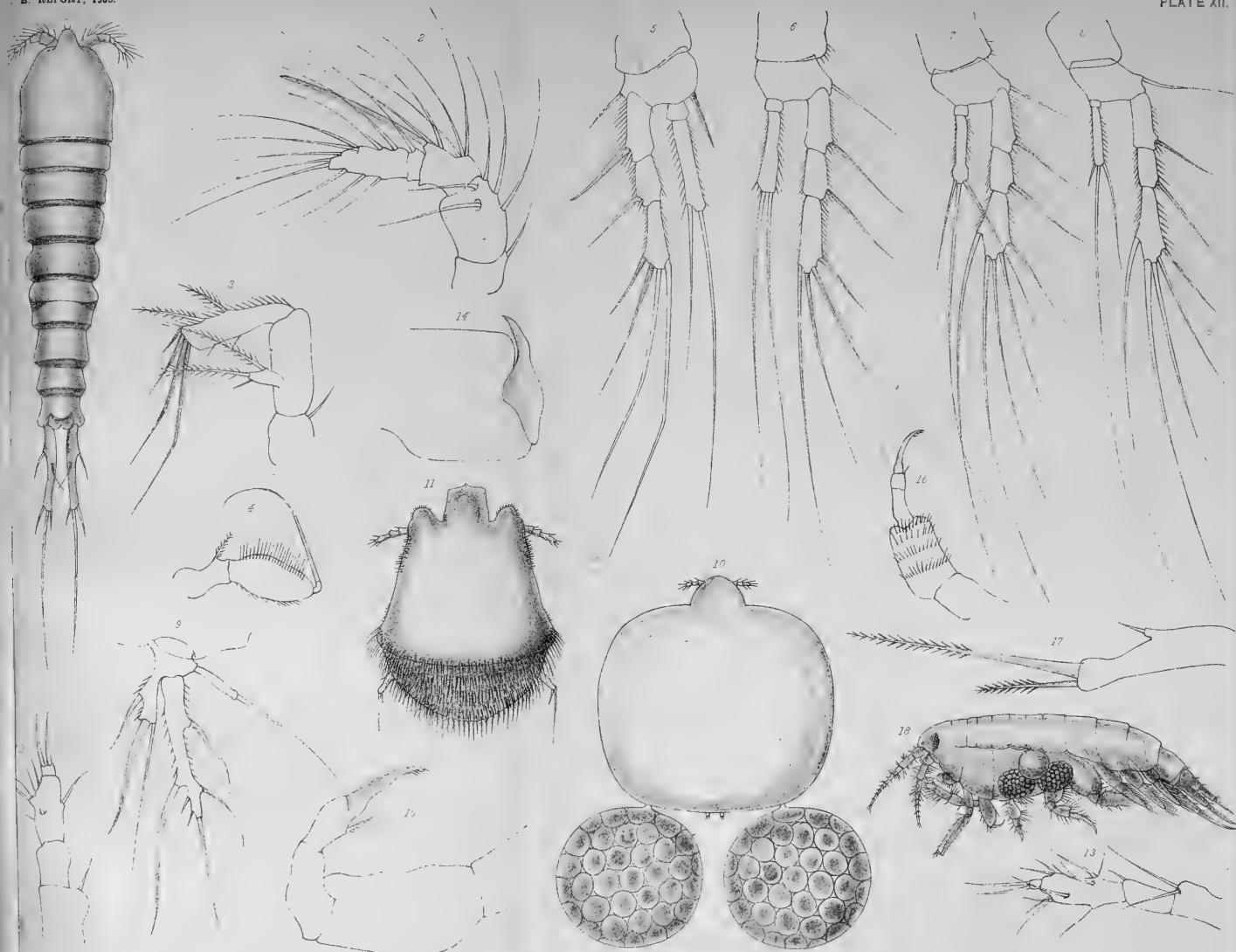
Spheronella aora, sp. n.

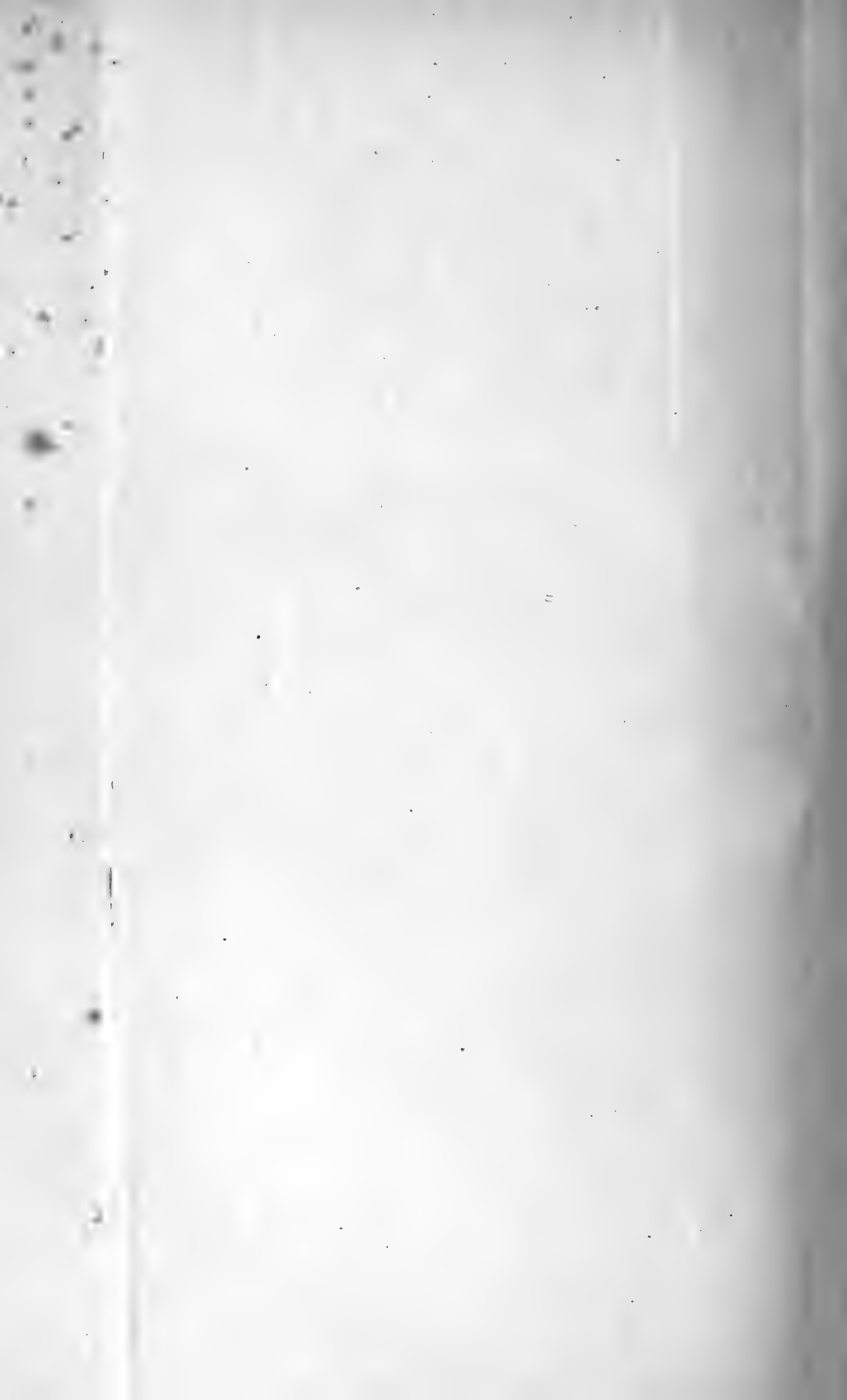
Fig. 10. Female, dorsal view	.	.	.	.	.	.	×	60.
Fig. 11. Male, dorsal view	.	.	.	.	.	.	×	180.











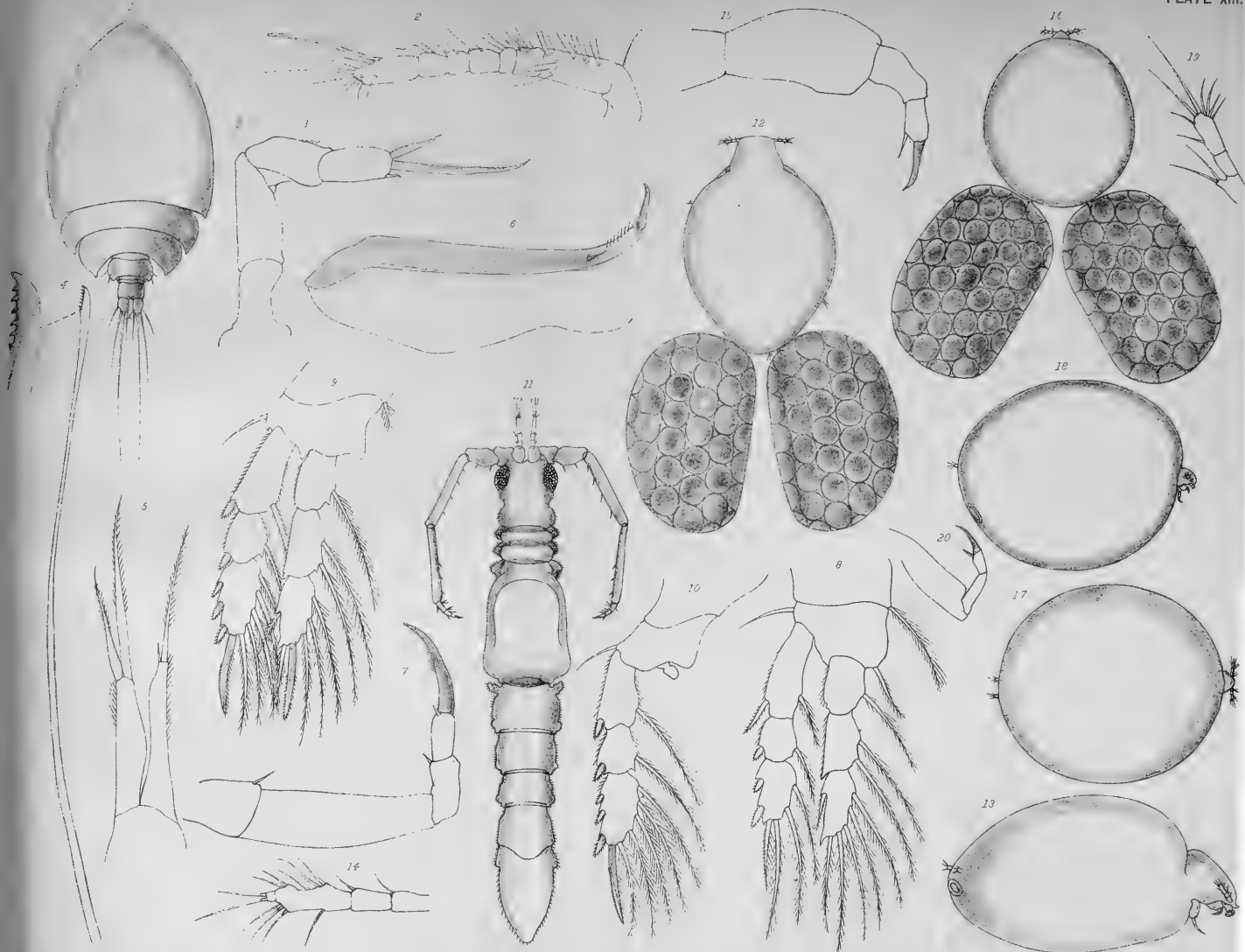




Fig. 12.	Antennule, female	.	.	.	.	.	×	780.
Fig. 13.	Antennule, male	.	.	.	.	.	×	780.
Fig. 14.	First maxilliped, female	.	.	.	.	.	×	780.
Fig. 15.	Second maxilliped, female	.	.	.	.	.	×	780.
Fig. 16.	Second maxilliped, male	.	.	.	.	.	×	780.
Fig. 17.	Foot of ? second pair	.	.	.	.	.	×	390.

Sphæronella minuta, T. Scott.

Fig. 18.	<i>Periculodes longimanus</i> with the <i>Sphæronella</i> in situ,	×	22.5.
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PLATE XIII.

Dyspontius curticaudatus, sp. n.

Fig. 1.	Female, dorsal view	×	80.
Fig. 2.	Antennule	×	263.
Fig. 3.	Antenna	.	.	.	.	.	×	520.
Fig. 4.	Mandible	.	.	.	.	.	×	390.
Fig. 5.	Maxilla	.	.	.	.	.	×	520.
Fig. 6.	First Maxilliped	.	.	.	.	.	×	350.
Fig. 7.	Second maxilliped	.	.	.	.	.	×	280.
Fig. 8.	Foot of first pair	.	.	.	.	.	×	187.
Fig. 9.	Foot of third pair	.	.	.	.	.	×	260.
Fig. 10.	Foot of fourth pair	×	260.

Arcturella dilatata, Sars.

Fig. 11.	Male, dorsal view	×	20.6.
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Sphæronella vararensis, sp. n.

Fig. 12.	Female, dorsal view	×	90.
Fig. 13.	Female, side view	×	120.
Fig. 14.	Antennule	.	.	.	.	.	×	780.
Fig. 15.	Second maxilliped	×	780.

Sphæronella minuta, T. Scott.

Fig. 16.	Female, with ovisacs
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Sphæronella minuta, var. *valida*.

Fig. 17.	Female, dorsal view	×	72.
Fig. 18.	Female, side view	×	780.
Fig. 19.	Antennule	.	.	.	.	.	×	780.
Fig. 20.	Second maxilliped	.	.	.	.	.	×	780.

VII.—A NOTE ON THE HATCHING OF THE CRAB (*CANCER PAGURUS*). By H. CHAS. WILLIAMSON, M.A., D.Sc., Marine Laboratory, Aberdeen.

In the summer of 1902 a quantity of the fry of the edible crab was distributed in the sea off the coast of Aberdeenshire.

Nine berried crabs (breester, pea-parten) were obtained chiefly in the neighbourhood of Aberdeen. They were kept in two concrete tanks until the larvæ hatched out. Shelter was afforded the crabs in cavities formed by building stones up on the sand-covered bottom of the tank. When the fry hatched out it was attracted to the glass front of the tank, from which side the light entered, and when present in quantity the fry formed a thick white cloud. The young crabs were drawn off into the carboys by means of a syphon. All the fry of the crab deposited near Fraserburgh and Findochty was in the first zoëa stage. The crab fry was disposed of as follows:—

August 6, 1902.—About 1 million set free about 1 mile north of Fraserburgh.

August 7, 1902.—About 2 millions set free about $\frac{1}{2}$ mile off Cairnbulg.

August 19, 1902.—About 1 million set free about $\frac{3}{4}$ mile off St. Combs.

September 15, 1902.—About $\frac{1}{2}$ million set free about $\frac{3}{4}$ mile north of Findochty.

The method of estimating the numbers of crab fry was as follows. The fry that was set free was provided by nine berried crabs, and at the low average of half a million eggs to each crab, should number $4\frac{1}{2}$ millions. The proportion of this total set free at each of the four above-mentioned places was apportioned approximately by the number of carboys required for the consignment.

The crabs hatched out in August, September, and October. The vitality of the crab fry was tested in the following manner. Crab fry were crowded into a glass jar. The water was heated to $17\frac{1}{2}^{\circ}$ C., and then allowed to cool. Next forenoon the majority was alive and lively.

On one of the journeys the water in one of the carboys was cooled to about 7° C. The crab fry in this carboy did not, at the end of the journey, appear to be in any better condition than those which had been filled with water at the temperature of the hatchery.

The crabs which furnished the fry were kept alive when the hatching was finished, and some lived until the spring of 1905. The history of the members of the 1902 group throws some light on certain of the problems of the life-history of this species. It has been already outlined.*

In January 1903 two of these crabs were dissected; one had died, the second was killed. In the former the ovary was white, with a very slight pink tinge. There were a few red eggs in a bunch near the oviduct. The eggs were degenerating; they were disorganised internally.

* Vide Williamson. "Contributions to the Life-histories of the Edible Crab (*Cancer pagurus*) and of other Decapod Crustacea, &c."—*Twenty-second Annual Report of the Fishery Board for Scotland, Part III.*, 1904.

One spermatheca was empty ; the other had a large quantity of sperms in it. The swimmerets had still some empty egg-capsules attached. In the crab which was killed the ovary was the colour of the external eggs. It was friable. The spermatheca contained a good quantity of sperms. The endopodites of the swimmerets were clean.

In October 1903 two of the crabs spawned. One which was killed had an ovary that appeared to be ripe ; the eggs measured $\cdot 37$ and $\cdot 4$ mm. in diameter. There was a copious supply of sperms in the spermatheca.

On January 13th 1904 another crab was found to have spawned. On February 14th 1904 two of the non-berried crabs were dead. In one, measuring 6 inches across, the ovary was small and white, but mottled to a considerable extent here and there with red eggs. This crab had evidently spawned this season, although the eggs had not remained attached to the swimmerets. There was a small quantity of sperms in each spermatheca. The second crab measured $7\frac{1}{8}$ inches across. The ovary was dropsical. There was a large quantity of sperms in both spermatheca. There were lots of empty egg-capsules on the endopodites of the swimmerets.

On October 31st 1904 there were five crabs remaining of the 1902 batch. One was berried. On November 19th 1904 two of the crabs were berried. In December 1904 and January 1905, three crabs were found dead. On January 12th 1905 two crabs remained ; one of these was berried. Both crabs were found dead on May 6th 1905. During the whole period not one of the crabs cast.

CASTING.—THE ABSORPTION AREAS ON THE CHELA.

In a previous paper I described the absorption which takes place on the three proximal joints of the chela at the time when the crab casts, whereby the withdrawal of the chela from the shell is facilitated. I was not aware at that time that a detailed description accompanied by drawings had been published by J. Couch.*

* J. Couch. "A particular description of some circumstances hitherto little known, connected with the process of Exuviation in the Common Edible Crab." *Twenty-sixth Annual Report of the Royal Cornwall Polytechnic Society*, 1858.

VIII.—ON THE TAY SPRAT FISHERY,

1904–1905.

By JOHN FLETCHER, University College, Dundee.

The sprat fishing during the past season has been exceptionally poor. Only 1348 crans of sprats, including young herrings, were taken out of the river this season, as against 14,966 crans during the season of 1883–1884.

The 1348 crans consisted of somewhere about 44 million young herrings and sprats, of which some 52 per cent., or 23 million, were young herrings measuring from 4·3 centimetres to 17·5 centimetres in length, and the other 21 million, or 42 per cent., were sprats measuring from 4 centimetres to 15 centimetres.

Of the 1348 crans, some 894 crans were sold as fresh fish and sent off to the markets of London, Birmingham, Manchester, Liverpool, and other English towns; and some 454 crans (containing over 7 million young herrings) were sold to local farmers for manure.

The 894 crans of fresh fish brought to the fishermen a sum of somewhere about £220, and the 454 crans of manure brought in only some £20.

A certain number of young herrings and sprats were also destroyed while the men were engaged at the sparling fishing further up the river.

During October, November, and December, 1904, the number of sprat boats engaged at the sparling fishing varied from 5 to 20, and each net brought up along with the sparlings from 1 to 6 buckets of young herrings and sprats per day. During the latter half of January 1905 the number of boats varied from 10 to 26, and these were getting from 3 buckets to 1½ crans of young herrings and sprats. Very few were caught during the month of February.

The young of other fishes are also annually destroyed by the sprat and sparling fishermen, but apparently not in any great quantities. The useful forms include the young of the whiting, cod, plaice, dab, flounder, and sparling, while among the inedible kinds were young and adult *agoni*, *cotti*, *liparis*, lumpsuckers, sand-eels, sticklebacks, &c.

The Broughty-Ferry winter herring fishermen and the sprat fishermen strictly observed the line of division suggested at the Local Enquiry of January 1904, viz.:—a line drawn between Broughty-Ferry and Tayport, the sprat fishers being restricted to the part of the river above that line, and the Broughty-Ferry men never going beyond it.

During the course of this season's investigations 46 samples of mixed sprats, young herring, and other fish were bought and examined. The 46 samples consisted of:—

Young Herring,	26,037
Sprats,	16,992
Young Whiting,	317
„ Cod,	136
„ Plaice,	68
„ Sparlings,	26
„ Flounders,	18
„ Dabs,	15
„ Lythe,	1

43,610

<i>Agonus cataphractus</i> ,	168
Sand-eels (<i>Ammodytes tobianus</i>),	40
Viviparous Blennies,	10
Lumpsuckers. <i>Cyclopterus lumpus</i> ,	9
<i>Gobius minutus</i> ,	9
Butter-Fish. <i>Centronotus gunnellus</i> ,	9
<i>Liparis montagui</i> ,	8
Pipe-fish, <i>Syngnathus</i> , sp.,	5
Fifteen-spined Stickleback,	2
Three-spined Stickleback,	1

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In most cases, also, the sprats and herrings were carefully measured with a view to determining the rate of growth of the species and the probable growth of the fish caught. These measurements will be dealt with on another occasion.

NUMBER OF SPRATS MEASURED.

October,	977
November,	3438
December,	2238
January,	2112
February,	2233

10,998

NUMBER OF HERRING MEASURED.

October,	733
November,	2983
December,	2269
January,	2287
February,	1983

10,255

The 43,000 sprats and young herring examined represented about one thousandth part of the entire season's catch. The catch was carefully inspected on every day when fish were landed throughout the season, but on some days no large samples were counted, a rough estimate only being made of the proportion of sprats and herrings which made up the catch. By these two methods the following Table has been drawn up, showing the approximate composition of the catch throughout the season. An asterisk denotes the days when the estimate was only a superficial one.

OCTOBER.

Date.	No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.
1904.				
October 20 . . .	1 $\frac{3}{4}$	2,520	47,880	50,400
„ 24 . . .	4	39,168	76,032	115,200
„ 27* . . .	1 $\frac{1}{2}$	12,960	30,240	43,200
„ 28 . . .	4	3,456	111,744	115,200
„ 31 . . .	4 $\frac{1}{4}$	33,048	89,352	122,400
	15 $\frac{1}{2}$	91,152	355,248	446,400

NOVEMBER.

Date.	No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.
1904.				
November 1 . . .	15	30,240	401,760	432,000
„ 2 . . .	34 $\frac{1}{2}$	59,616	933,984	993,600
„ 3 . . .	$\frac{1}{8}$	288	3,312	3,600
„ 4 . . .	2	19,584	38,016	57,600
„ 5* . . .	4	34,560	80,640	115,200
„ 7 . . .	6	58,215	174,645	232,860
„ 10 . . .	9	49,248	4,875,552	4,924,800
„ 11* . . .	3	17,280	69,120	86,400
„ 12* . . .	3	17,280	69,120	86,400
„ 14 . . .	23	331,200	331,200	662,400
„ 15* . . .	31 $\frac{1}{2}$	272,160	635,040	907,200
„ 16 . . .	58	668,160	1,002,240	1,670,400
„ 17* . . .	30 $\frac{1}{2}$	404,064	1,474,336	1,878,400
„ 18* . . .	$\frac{3}{8}$	3,240	7,560	10,800
„ 19* . . .	1 $\frac{1}{2}$	12,960	30,240	43,200
„ 21 . . .	23 $\frac{1}{2}$	257,184	419,616	676,800
„ 22* . . .	49	987,840	423,360	1,411,200
„ 23 . . .	16 $\frac{1}{2}$	456,192	19,108	475,300
„ 24 . . .	78 $\frac{1}{2}$	1,763,424	497,376	2,260,800
„ 25* . . .	24 $\frac{1}{4}$	558,720	139,680	698,400
„ 26* . . .	17 $\frac{1}{2}$	403,200	100,800	504,000
„ 28 . . .	32 $\frac{1}{2}$	664,560	271,440	936,000
„ 29* . . .	11 $\frac{3}{4}$	236,880	101,520	338,400
„ 30 . . .	10 $\frac{3}{4}$	275,544	34,056	309,600
	485 $\frac{3}{4}$	7,581,639	12,133,721	19,715,360

DECEMBER.

Date.	No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.
1904.				
December 1* . .	3	69,120	17,280	86,400
„ 5 . .	1 $\frac{3}{4}$	20,160	30,240	50,400
„ 7 . .	66 $\frac{1}{4}$	896,760	1,011,240	1,908,000
„ 8* . .	68 $\frac{1}{4}$	982,800	982,800	1,965,600
„ 9 . .	9 $\frac{1}{2}$	191,520	82,080	273,600
„ 10* . .	4 $\frac{1}{2}$	90,720	38,880	129,600
„ 12 . .	23 $\frac{1}{2}$	534,672	142,128	676,800
„ 14 . .	9	150,336	108,864	259,200
„ 15* . .	2 $\frac{1}{4}$	45,360	19,440	64,800
„ 16 . .	$\frac{1}{4}$	6,896	504	7,200
„ 19 . .	5	100,800	43,200	144,000
„ 20* . .	50 $\frac{3}{4}$	876,960	584,640	1,461,600
„ 21* . .	35 $\frac{1}{2}$	613,440	408,960	1,022,400
„ 22 . .	7 $\frac{1}{4}$	116,928	91,872	208,800
„ 23* . .	35	504,000	504,000	1,008,000
„ 26* . .	24 $\frac{1}{2}$	211,680	493,920	705,600
„ 27 . .	17	141,984	347,616	489,600
„ 28* . .	27	233,280	544,320	777,600
„ 29* . .	13	112,320	262,080	374,400
„ 31* . .	5	43,200	100,800	144,000
	408 $\frac{1}{4}$	5,942,736	5,814,864	11,757,600

JANUARY.

Date.	No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.
1905.				
January 4* . . .	8 $\frac{3}{4}$	151,200	100,800	252,000
„ 5 . . .	19	377,568	169,632	547,200
„ 6* . . .	9	155,520	103,680	259,200
„ 9 . . .	4 $\frac{1}{4}$	78,336	44,064	122,400
„ 10 . . .	19	383,040	164,160	547,200
„ 13 . . .	97 $\frac{1}{4}$	2,212,632	588,168	2,800,800
„ 14* . . .	22	506,880	126,720	633,600
„ 16 . . .	4 $\frac{1}{2}$	117,936	11,664	129,600
„ 17* . . .	1 $\frac{1}{2}$	34,560	8,640	43,200
„ 18 . . .	42 $\frac{3}{4}$	861,840	369,360	1,231,200
„ 19* . . .	64	1,474,560	368,640	1,843,200
„ 20 . . .	66 $\frac{1}{4}$	1,602,720	305,280	1,908,000
„ 21* . . .	40	967,680	184,320	1,152,000
„ 23 . . .	21 $\frac{3}{4}$	532,440	93,960	626,400
„ 24* . . .	2 $\frac{1}{2}$	57,600	14,400	72,000
„ 25 . . .	4	87,552	27,648	115,200
„ 26* . . .	2	46,080	11,520	57,600
„ 27 . . .	$\frac{1}{4}$	6,048	1,152	7,200
	428 $\frac{3}{4}$	9,654,192	2,693,808	12,348,000

FEBRUARY.

Date.	No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.
1905.				
February 1 . . .	$\frac{1}{4}$	5,472	1,728	7,200
„ 3* . . .	$\frac{1}{2}$	10,080	4,320	14,400
„ 7 . . .	1	14,976	13,824	28,800
„ 8* . . .	3 $\frac{1}{4}$	51,480	42,120	93,600
„ 9 . . .	2 $\frac{3}{4}$	49,896	29,304	79,200
„ 13* . . .	$\frac{3}{8}$	6,480	4,320	10,800
„ 14 . . .	$\frac{1}{4}$	3,024	4,176	7,200
„ 20* . . .	$\frac{1}{4}$	3,600	3,600	7,200
„ 23 . . .	$\frac{3}{4}$	17,064	4,536	21,600
„ 24 . . .	$\frac{1}{4}$	5,112	2,088	7,200
	9 $\frac{3}{8}$	167,184	110,016	277,200

1904-1905.

Months.	Estimated No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.	Estimated Percentage of Young Herring.
October, . . .	15½	91,152	355,248	446,400	20·4
November, . . .	485¾	7,581,639	12,133,721	19,715,360	38·5
December, . . .	408¼	5,942,736	5,814,864	11,757,600	50·5
January, . . .	428¾	9,654,192	2,693,808	12,348,000	78·2
February, . . .	9½	167,184	110,016	277,200	60·3
	1,347½	23,436,903	21,107,657	44,544,560	50·4

It will be observed that the percentage of herring gradually and steadily increased from the commencement of the season until January, and was still at a high level when the fishing closed.

TAY SPRAT FISHING INVESTIGATIONS—1904-1905.

Causes of Failure of the Fishing.

This season's sprat fishing has been one of the poorest for many years, great distress prevailing amongst the fishermen during the first half of the season, or from October till the end of December.

During that time both fishermen and buyers were losing money, and, at most, the fishermen were only able to pay for the wear and tear of gear, dock dues, and victualling.

The principal causes of complaint were:—

- (1) The scarcity and poor quality of the fish.
- (2) The low prices obtained for the fish.
- (3) The alleged excessive railway rates.

The mild open winter, want of south-easterly gales, and almost total absence of spates may have something to do with the scarcity of fish in the river, but, so far, I have not been able to prove that such causes have any influence upon the movements of the fish.

As the bag-net captures all sizes and every kind of fish that enters the river, it follows that the very large numbers of young sprats and young herring, together with the usually considerable numbers of young cod, whiting, Agoni, shrimps, &c., all go to make up the so-called rubbishy stuff sent from Dundee to the English markets.

This mixture of fish has no chance beside the prime sprats sent from Inverness, where the fishing is carried on by means of drift-nets.

The railway companies charge from 6s. to 10s. per barrel for fish sent to the English markets. This rate is doubtless a severe handicap on the trade considering the small value of the produce, though it can scarcely be deemed high considering the bulk of the goods and the distance from Dundee to the great English towns

General Account of the Fishing.

By common agreement among the fishermen, the Tay sprat fishing begins on the 25th of September and ends on the 25th of February.

This year's regular fishing, however, did not begin until the 20th of October, owing to the scarcity and poor quality of the fish.

The fishing boats are small yawls or smacks, from 38 to 48 feet along the keel, and manned by two, three, or four of a crew, the usual number, however, being two during poor seasons and three or four when fish are very plentiful. Each boat is valued at somewhere about £70, the net alone costing £12.

Some 29 boats are registered at the ports of Dundee and Perth, but the majority of these belong to Newburgh, St. Andrews, Easthaven, Carnoustie, Tayport, and Broughty-Ferry.

The boats go out either in the morning or afternoon, according to the abundance of fish or state of the tide, and fishing is continued throughout the night.

The fish are brought into the Dundee tidal-basin in the morning and are usually sold by auction, the auctioneer getting $3\frac{1}{2}$ to 4 per cent. of the gross return.

The fish are caught by means of a huge conical bag-net, which measures from 40 to 52 yards in length, with a mouth of from 21 to 24 feet square. I measured one as it lay stretched out on the quay and found it to be some 42 yards in length, with a mouth 23 feet square.

The mouth of the net is attached to two booms, an upper boom, 23 feet in length, which floats on the surface of the water, and a lower boom of the same length, weighted with iron, which sinks to various depths according to the strength of the tide.

The net consists of four parts, each part with a size of mesh smaller than the preceding part.

The first part attached to the two booms was 13 yards long, with a mesh of $1\frac{1}{8}$ of an inch from knot to knot, or, according to the fishermen, of 36 rows of meshes to the yard.

The second part is known as the "enter"; it measured 10 yards in length and had a mesh of $\frac{7}{8}$ of an inch from knot to knot, or, according to my informant, of 52 rows of meshes to the yard.

The third part of the net is known as the sleeve; it was 3 yards in length, with a mesh of $\frac{5}{8}$ of an inch, or 64 rows of meshes to the yard.

The fourth part of the net is known as the sprat-end; it measured 19 yards in length and had a mesh of $\frac{5}{16}$ of an inch from knot to knot, or, according to the fishermen, it contained 110 rows of meshes to the yard; the last three yards of the sprat-end were used as a tail end for hauling the net on board.

The Tay sparling fishing begins and ends at the same time as the sprat fishing, and is engaged in by the same men, who use the same boats and bag-nets but attach a small meshed herring-end or tail to the nets in place of the usual sprat end.

The sparling fishing is usually carried on when sprats and herring are not very plentiful in the river, and is usually confined to the upper parts of the estuary or from four to twelve miles above or west of the Tay Bridge.

The majority of the sprat and sparling boats are too old and rickety for any other kind of fishing except river-fishing. Their deck construction, accommodation, and gear are quite unsuited for winter herring fishing outside the river. A good many winter herring, however, are caught in the river along with the sprats and young herring during the months of January and February.

The sprat and sparling fishermen take part in various occupations during the summer time. Some of the men take part in the Tay salmon fishing; a few work on board the river passenger steamers, and

boats, &c.; a few are tradesmen (masons, &c.); while the rest are general labourers.

Tay Sprat-Fishing Grounds.

The Tay sprat-fishing grounds are included in that part of the estuary extending from Invergowrie and Balmerino, some 3 miles above or west of the Tay Bridge, down to, or a little beyond, Tayport and Broughty-Ferry, between 4 or 5 miles east of the Tay Bridge.

From Broughty-Ferry, the estuary increases uniformly in width as far as 3 miles above the Tay Bridge, where it is $2\frac{3}{4}$ nautical miles wide.

At Dundee it is $1\frac{1}{4}$ nautical mile in width, and at Broughty-Ferry, some $4\frac{1}{4}$ miles below the Tay Bridge, the estuary is only $\frac{3}{4}$ mile across.

Many sandbanks extend over this particular part of the estuary, which are dry 4 to 7 feet at low water, the width of the navigable channel being about $\frac{5}{8}$ mile.

Sandbanks also exist in the main channel itself, composed of cleaner and coarser sand than most of the surrounding sandbanks. Contrary to expectation, the sandbanks of the Tay are found to vary very little in form from one year's end to another. Extensive flats and sandbanks are present on either side of the main channel above or west of the Tay Bridge.

Abreast of Invergowrie and Ninewells, the main channel is marked off by two red and two black buoys; and forms here a very important sprat and herring fishing ground.

About opposite the west end of Dundee an important sandbank exists, some 150 yards in width at low water. The deep channel on the south side of it formed the principal ground for this and last year's sprat and herring fishing. This particular sandbank is known as the Middle Bank, and its narrow east end is marked off by the Chequer buoy.

A somewhat variable and extensive shoal projects from the southern shore of the estuary, about half-way between Newport and Tayport; it is called the Newcome Spit, and consists of a mass of clean sand and shells six times as coarse as the Middle Bank. The neighbourhood of the Newcome Spit is also a favourite sprat and herring fishing ground.

At Broughty-Ferry there are no sandbanks, and the river here is fully 10 fathoms deep at low water.

Seaward of Broughty-Ferry the estuary widens rapidly, and the bottom consists largely of coarse sand full of rounded water-worn stones.

At Monifieth Bay this material is said to form a suitable spawning ground for winter herring.

Tides.

Spring tides flow up the river Tay as far as two miles above the city of Perth, and sprats and herring are got by the sparring fishermen as far up as Newburgh, but only in very small quantities.

Low water of ordinary spring tides at Dundee Harbour is 7.5 feet below ordnance datum, and high water of ordinary spring tides is $16\frac{1}{2}$ feet above that level. The extreme range of high water at Dundee varies between 19 feet 6 inches and 3 feet 7 inches, and extreme low tides sometimes fall 1 foot 5 inches below low water of ordinary spring tides.

The tides have an important bearing upon the quantity of fish caught in the river, and also restrict the fishing to those parts of the river where the currents are strong enough to open the bag-nets.

During the flood of neap tides the currents are too weak to open the nets, and fishing can only take place then during ebb-tide, while during

the height of spring tides the currents in the neighbourhood of Craighead and Newcome Spit are too strong, and occasionally damage or carry the nets away altogether.

Fishing is also entirely stopped for a short time, extending from half-an-hour to three-quarters of an hour, during the slack water between tides.

Many of the fishermen are of opinion that most of the fish enter the river during spring tides and make their way to the sea again as the tides slacken; this, however, was not borne out by the daily returns of the fishing during the past season.

The main mass of the flood tidal current, after sweeping through between Broughty-Ferry and Tayport, flows in the direction of West-Ferry Bay and the Stannergate, then south-west between the Chequer Buoy and the Newcome Spit. It next flows west between the Middle Bank and the Fife shore, then north again in the vicinity of the Tay Bridge to Ninewells and Invergowrie Bay. The returning ebb tide flowing in the opposite direction passes over much the same course.

All the important sprat and herring fishing-grounds lie in the above course, and the fish when not very plentiful in the estuary appear to always follow more or less these main tidal currents on their way from and to the sea. When the fish are very plentiful, on the other hand, they are caught in all parts of the estuary.

The presence of the flood tide is perceived on the north side of the estuary in several ways. First, the saltiness of the water at spring tides upon the north shore is between 10 and 25 per cent. greater than that upon the south shore till the ebb tide has fairly commenced. Secondly, the current of the flood tide is so strong in the vicinity of Dundee as to give an inclination to the surface of the water, so that at half flood the level is 2 to 3 inches higher than it is on the opposite side of the estuary.

The deeper parts of both tidal currents are much saltier and, during the cold months, warmer, than the surface waters; but there is generally a greater difference in salinity and temperature between the surface and bottom layers of water upon the flood than upon the ebb, these layers tending to intermix somewhat less upon the flood-tide than upon the ebb.

At the Abertay Lightship stationed at the mouth of the Tay, the saltiness of the surface water, near low water and during heavy land floods, is sometimes as low as two-fifths of that of sea-water.

The normal ratio, however, of sea-water to land-water in the estuary is such that at the middle of its length—at Dundee—there is just as much fresh water as salt, and at the Pile Lighthouse, $\frac{1}{4}$ of a mile below Tayport, the quantities of sea-water and land-water are, on the average, as 2 to 1. The ratio of the land-water to sea-water at Dundee usually fluctuates between one-fifth and four-fifths.

So far as I can make out meanwhile, the movements of the sprats and herring in the river are not influenced to any marked extent by variations in temperature, although both kinds of fish appear not to wander very far from the slightly warmer water of the main flood tidal currents.

Some Notes on the Natural History of the Sprat and Winter Herring.

Sprats and winter herring frequent bays, inshore waters, and estuaries. They usually ascend the estuaries of rivers in large numbers during the months of October, November, December, January, and February. The main shoals appear to remain in the Tay estuary for short periods, extending from two to five or more days at a time, and then gradually make their way to the sea again.

Sprats and immature herring are amongst the most timid and restless of all fishes. They swim usually in separate shoals, but in the estuary of the Tay, where the main channel is so shallow and narrow, they very often mix and swim together.

Hardly any two fish in the sea have so many and varied enemies as the sprat and herring. This incessant persecution by numerous enemies, and consequent restlessness, may possibly partially account for the presence of both fish in such large numbers in the estuaries of rivers.

The fishermen, in trying to explain the presence of the fish in such large numbers in the Tay estuary, believe that the sprat and herring have a liking for brackish waters, and some scientists are under the impression that the fish seek the colder waters.

Several considerations, however, seem to be against such ideas. Both fish, while in the estuary, appear to remain in the main tidal currents, where the water is somewhat warmer than the surrounding waters. Experiments also show that in very cold waters fishes give up feeding altogether, probably because the ferments upon which digestion depends do not act, or at anyrate very slowly.

The fishermen also believe that the fish ascend the estuary to feed on the small organisms in the water, but this is also more or less erroneous. The majority of the herrings' stomachs examined were found to be empty; only a few contained a very small quantity of crustacea, while the sprats' stomachs were invariably found to be quite empty. Moreover, in the river at this season, the fish would get little or no food material to swallow, as careful examination of samples of water have shown.

Fishermen are also of opinion that the state of the tides is related to the quantity of fish in the river, that during spring tides the fish are more plentiful than during neap tides; but after carefully comparing the daily catches with the state of the tide, I am unable to show a close connection. Certainly on several occasions the best fishing was at or near the spring tides, *e.g.*, November 23, December 7 and 22, and January 17-21; but there was fairly good fishing during neap tides about November 1 and 15, December 27, and very good about January 12.

They, again, believe that rough weather, especially strong south-easterly gales, drive the fish into the river, but this also I am unable to prove.

During the great scarcity of fish in the month of November, I questioned many of the fishermen as to the state of the water in the river. One and all believed that they had never seen such a lot of fire (phosphorescence) in the river as during that time. This phosphorescence, along with the clearness of the water, enabled the fish to see the nets and thus avoid them. This I believe to be partially true, for if the fish swim in small, narrow, separate shoals, as they appear to do when not very plentiful in the river, then they might conceivably take fright at the glowing anchor and the chain, &c., and thus at the same time swim clear of the open mouth of the bag-net. Against this idea, however, is the fact that very seldom were the nets brought up absolutely empty, while nearly every boat managed to capture from $\frac{1}{4}$ to 3 crans of fish. During the daytime, however, it is a fact that little or no fish are caught if the water is very clear and the fish not very plentiful in the river. The fish avoid the light and swim at a much lower level, and thus avoid the open mouth of the bag-net.

IX.—GENERAL INDEX TO THE SCIENTIFIC REPORTS OF THE FISHERY BOARD FOR SCOTLAND, 1883-1904, WITH A LIST OF THE PAPERS CONTAINED IN THEM. Prepared by Dr. THOMAS WEMYSS FULTON, F.R.S.E., Superintendent of Scientific Investigations.

For some years it has been felt as a want, both by the staff of the Board and by those engaged elsewhere in fishery investigations and research, that there existed no general index to the numerous scientific papers contained in the Annual Reports of the Fishery Board. These reports now number over a score, extending back to the year 1882, and they necessarily contain a large amount of matter dealing with marine biology and physics, and relating to fisheries and fishery problems. I have endeavoured to supply the want referred to by the compilation of the index and list of scientific papers printed in the following pages.

In the index the numbers referring to the various reports are enclosed within brackets; from the sixth report onward, that namely for 1887, the reference is to Part III. of the Annual Report, the reports since the year named being divided into three parts, the third of which is that devoted to scientific investigations. In the list of papers the figures in brackets refer to the year of publication.

LIST OF PAPERS.

Barrett, Dr. W. H.

Note on the Liver of a Haddock in which a Sand-eel was partly Embedded. **3**, p. 70, Pls. III.-V. (1885).

Beard, Dr. J.

On the Development of the Common Skate (*Raja batis*). **8**, p. 300, Pls. IX.-XI. (1890).

Brady, Professor G. S.

1. Notes on Entomostraca. **5**, p. 328, Pl. XIX. (1887).
2. Description of a new series of *Cyclops*. **6**, p. 232 (1888).

Brook, George.

- 1 and 2. On the Development of the Herring. **3**, p. 32, Pl. I. (1885); **4**, p. 31, Pls. I., II. (1886).
3. Note on some of the specimens sent in by the Officers of the Board. **3**, p. 67 (1885).
4. Report on the Herring Fishery of Loch Fyne and the adjacent districts during 1885. **4**, p. 47 (1886).
5. Report on the Food of the Haddock. **4**, p. 128 (1886).
6. Report on the Food of the Cod. **4**, p. 134 (1886).
7. Ichthyological Notes. **4**, p. 222, Pl. IX. (1886).
8. The Spawning-period of the British Food-fishes. **4**, p. 242 (1886).
9. Notes on the Food of Young Gadidae. **5**, p. 326 (1887).
10. Notes on the Spawning of the Pike. **5**, p. 347 (1887).

Brook, George, and W. L. Calderwood.

Report on the Food of the Herring. **4**, p. 102 (1886).

Brook, George, and Dr. Thomas Scott.

List of the Marine Fauna collected at the Tarbert Laboratory during 1885. **4**, p. 231 (1886).

Calderwood, W. L.

1. Notes on the Copepods of Loch Fyne. **4**, p. 147 (1886).
2. Notes on the Greenland Shark (*Leomargus microcephalus*). **4**, p. 228, Pl. X. (1886).
3. Notes on an Intra-uterine specimen of the Porbeagle (*Lamna cornubica*). **6**, p. 263 (1888).

Clarkson, Dr. R. D.

On the Nutritive Value and Relative Digestibility of Fresh Fish. **5**, p. 221 (1887).

Cleve, Professor P. T.

Report on the Phyto-plankton collected on the Expedition of H.M.S. "Research," 1896. **15**, p. 297, Pl. VIII.

Cunningham, J. T.

Zones of Growth in the Skeletal Structures of Gadidae and Pleuronectidae. **23**, p. 125 (1905).

Daniel, Dr. Alfred.

Abstract of a Report on the Fishery Statistics of Scotland. **7**, p. 178 (1889).

Dannevig, Harold C.

- 1 to 5. Reports on the Hatching Operations at Dunbar Marine Hatchery during the Spring Season, 1894, **12**, p. 210 (1894); 1895, **13**, p. 123 (1895); 1896, **14**, p. 150 (1896); 1898, **17**, p. 205, Pl. VIII. (1899); 1899, **18**, p. 330 (1900).
6. The Influence of Temperature on the Development of the Eggs of Fishes. **13**, p. 147, Pl. I. (1895).
7. On the Rearing of the Larval and Post-larval Stages of the Plaice and other Flat-fishes. **15**, p. 175, Pl. IV. (1897).
8. Report on the Operations at Dunbar Marine Hatchery for the period July 1896 to December 1897, with some Notes on Rearing Experiments with Flat-fishes. **16**, p. 219 (1898).
9. On the Rate of Growth of Plaice. **17**, p. 232, Pl. IX. (1899).
- 10 and 11. Reports on the Hatching Work at the Marine Hatchery, Bay of Nigg, Aberdeen, during the Spring Season, 1900, **19**, p. 229 (1900); 1901, **20**, p. 440 (1902).

Day, Dr. Francis.

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X.—ICHTHYOLOGICAL NOTES.

By Dr. T. WEMYSS FULTON, F.R.S.E., Superintendent of Scientific Investigations.

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THE YOUNG OF THE CONGER (*Leptocephalus*).

In last year's Report I described and figured two specimens of *Leptocephalus*,* both taken in the Moray Firth, one in December and the other in February. On 4th May last the Laboratory attendant, while using a small trawl of very fine netting, fitted on an iron frame, like a dredge-frame, for the capture of newly-transformed flat-fishes, caught a third specimen, and part of another. The drag was made in Aberdeen Bay, opposite the Bathing Station, in from four to five fathoms of water, and the fish in the net were brought ashore alive and placed in a tank in the tank-house at the Marine Laboratory. Next morning, on examining the tank, the *Leptocephalus* was discovered alive, concealed in a chink. Besides this living specimen, the head part of another of apparently the same stage and dimensions was found adhering to the net; it had been cut off about a centimetre behind the head, probably by the action of the edge of the iron frame dragged along the bottom. Other similar hauls in the same locality were made on succeeding days, but no other specimens were secured.

The living specimen was transferred to a large glass basin, on the bottom of which sand was strewn, and a stone with sea-weed growing on it was placed in the centre. Tow-nettings and also collections of crustacea from the beach, as well as minced mussels latterly, were placed in the tank. Here the young conger lived and thrived until 13th June, when it disappeared. It was observed by the attendant in the morning, but was missed a few hours later. The overflow was carried away by two S-shaped glass tubes, acting as syphons, and removing the water at a little distance below the surface. The bore of these tubes was about four millimetres in diameter, and it is not easy to understand how the *Leptocephalus* could have made its exit through either of them.

As it was desired to rear it if possible, it was not removed from the vessel for examination. So far as could be judged, it was about five inches in length and about a centimetre in breadth, and corresponded closely to the second of the two forms described last year, and identified as *L. punctatus*, of Kaup. The myotomes and the median row of black dots could be seen distinctly, but none were observed on the ventral margin. It was slightly whitish, but translucent and almost trans-

* *Twenty-Second Annual Report of the Fishery Board for Scotland.* Part III., p. 281.

parent, and its eyes were the only conspicuous part of it, the silvery lustre contrasting with the intense black pigment, of which there was also a somewhat triangular patch on the upper surface.

At first it habitually lurked in concealment under the overhanging edge of the stone, only its head being visible. On being disturbed its first movement was to withdraw the head also, but if the disturbance continued, it came out from its lair and swam slowly round the vessel, close to the sand, with an undulatory or serpentine movement, stopping every now and again and swaying its head to one side or the other as if examining the bottom, which it occasionally tapped suddenly with its snout. Later, it took up a position on the top of the stone, among the weeds, with its body entwined among the stems.

In the part of the other specimen, examined later after preservation in formaline, the depth behind the head was 6mm. and the thickness 3mm., the diameter of the eye being 1.5mm. The lower jaw was conspicuously longer than the upper, projecting considerably beyond it; minute dots of dusky pigment existed on the tip of the snout, and still more markedly on and around the tip of the lower jaw, extending backwards under it. The tissues had a solid consistence. This specimen thus appears to differ somewhat from the one I described last year.

THE ANCHOVY (*Engraulis encrasicolus*).

In some previous reports I have described the occurrence of the anchovy in Scottish waters.* On 29th June, last year, a specimen was taken in a sparling (or smelt) net, near Creetown, Wigton Bay, and was sent by Mr. W. Poole, of that place, to Mr. R. Duthie, the Fishery Officer of the district, whom I have to thank for the specimen. Compared with other Scottish specimens that have come into my hands, it is unusually large. The end of the tail is damaged, and its length, as it is, is 178mm., or 7 inches, but when perfect it probably measured about 184mm. According to Day, the anchovy rarely exceeds 6½ inches, but he mentions that Dunn has obtained specimens off the Cornish coast measuring eight inches in length.

THE CATFISH (*Anarrhichas lupus*).

The spawning period of this fish has not yet been well determined; it may therefore be worth while recording that on 6th August last, among a number which were caught by a trawler in 49 fathoms, six miles north-west of Foula Island, which lies to the westwards of the Shetlands, some of the females had the eggs well advanced. The fish were opened by Captain Samuel Caie and the eggs were sent in bottles to the Marine Laboratory. In three cases the eggs measured from 3mm. to 4mm. and were obviously immature, but in one instance they were fully mature, measuring 6mm., and they were isolated and separate, and apparently ready for extrusion.

M'Intosh and Masterman† are probably right in supposing that the main spawning time of this fish is from November to January, with a margin on either side; but the existence of a fully ripe female at the beginning of August shows that spawning may begin much earlier than November.

AN ALBINO PLAICE.

I am indebted to Mr. James Robb for a specimen of an albino plaice

* Eighth Annual Report of the Fishery Board for Scotland, Part III., p. 351;
Twentieth. *ibid.*, p. 539.

† British Marine Food Fishes, p. 201.

which was caught by the steam trawler "Chinkiang," 25 miles S.-E. by E. from Aberdeen in March last, and which was received alive at the Marine Laboratory. It was $14\frac{1}{2}$ inches in length and was everywhere destitute of pigment, except on the upper surface of the head and gill-cover and at the root of the ventrals, where a small patch existed. The ocular side was as white as the blind side. The fish was put into a tank along with other flat-fishes and was exceedingly conspicuous as it lay on the bottom. It lived for over two months and was found dead on 19th May.

In the Report for last year* I described another albino plaice, so that they are not extremely rare.

The specimen above described was interesting also as giving an example of the tenacity of life in this species. It was caught by the "Chinkiang" about two in the morning, put with the other plaice and brought to market; it was being packed in a box in the usual way about ten o'clock, when it was discovered by Mr. Robb, who sent it to the laboratory in fresh water as preferable to the impure water of the harbour.

THE SPAWNING OF THE COD IN AUTUMN IN THE NORTH SEA.

Under this title, I contributed last year to the *Publications de Circonsance* (No. 8, 9) of the International Council for the Exploration of the Sea, a paper in which I described the occurrence of shoals of spawning cod in autumn, on a ground known as the "Reef," lying about 180-190 miles E. by N., or E. by $\frac{3}{4}$ -N., from Aberdeen, that is to say, close to the deep water of the Norwegian Channel, and about seventy or eighty miles from the coast of Norway. A few additional observations on the subject may be here mentioned.

Last year the fishing on this ground was begun about the middle of July by one of the steam liners (the "Vigilant"), and later by others, and it was continued till late in the year. Mr. Forbes, the skipper of this vessel, informed me that the grounds on which they were fishing were situated 195 and 196 miles E. $\frac{3}{4}$ -N. from Aberdeen in 55 and 56 fathoms of water. He states that there is another patch of rough ground about 50 miles to the northwards where they also get spawning cod in autumn. In August I noticed the ripe cod in the fish-yards and traced them to the "Reef" grounds, and I got Mr. Forbes to keep a tally of the cod taken on two of his voyages. The first occasion was 30th August and the position was 165 miles E. $\frac{3}{4}$ -N., the depth being 56 fathoms. The number of cod caught was 18 score, or 360 fish, and the number from which the milt or eggs were observed to be running as they were brought on board was 37 males and 28 females, or nearly 19 per cent. On this occasion, I was informed, the vessel was not quite on the proper grounds; they were a little too far north and, owing to fog, they were unable to see the sun to determine their position. When on the right ground, they say that practically all the cod taken are either spawning or full, or spent. The next occasion was the 14th September, the position being nearly the same, viz., 196 miles E. $\frac{3}{4}$ -N., and the depth 55 fathoms. Forty-one score of cod, or 820 fish, were taken, and the number observed to be "running" was 83 females and 67 males, or again nearly 19 per cent. One or two ling were also found to be spawning, but as a rule they were beginning to "fill up."

It is of interest to note that the largest average catches of cod obtained by the Aberdeen steam-liners are taken from the area in

which these grounds are situated. The statistics of the vessels in 1903, for which I am indebted to Professor D'Arcy Thompson, show the following, in cwts. per 100 lines used, for Square XX., in which the "Reef" lies:—

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Cod, - -	30·0	60·6	69·6	92·8	114·8	161·1	143·1	109·6	..
Codling, - -	5·75	2·6	4·6	37·5	5·24	4·69	6·2	..

And the complete statistics for the various Squares in the North Sea, in which the vessels fished in the last five months of the year are these:—

	XIII.	XVI.	XVII.	XVIII.	XX.	XXI.	XXII.	XXIII.	XXIV.	XXV.	XXVI.	XXVIII.	XXIX.
August, - -	114·8	55·1	..	..	..	..	63·7	..	0·8
September, -	..	75	..	..	161·1	..	..	13·3	35	..	..	..	0·6
October, - -	143·1	..	..	31·9	50	174·2	..	..	39·5
November, -	40·9	23·6	109·6	..	20·2	63·5	..	..	..	..	44·6
December, -	83·3	..	69·	31·8	..	..	42·4	54·	..	..	..	34·1	54·1

Square XXV., it may be said, lies to the south of XX., contiguous with it.

Dr. Hjort, of the Norwegian Fishery Board, who visited the grounds in the "Michael Sars," the Norwegian investigation steamer, last August, has pointed out as an interesting fact that the temperature at the place where the spawning cod are found in autumn is the lowest for the year in the locality, while on the coastal banks, where the spawning takes place in spring, the temperature is also at the lowest during the spawning time.

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